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EDISON ELECTRIC INSTITUTE BULLETIN

DECEMBER, 1936

Government Ownership: Theory vs. Experience . . . . . C. W. KELLOGG 477

Electric Power for the Farmer . . . . . M. C. BURRITT 481

The Case Against Government Ownership . . . . . FRANK A. NEWTON 485

Handbooks for the High School Debates 489

Planning for Emergency System Operation . . . . WILLIAM R. HAMILTON 490

Regulation of Electrical Utilities in Foreign Countries . ALEXANDER MAXWELL 497

Operation of Oil Insulated Transformers On a Temperature Basis . . . . . ELWOOD A. CHURCH 501

All Power Companies Invited to Compete for Coffin Award 509

Prime Movers Committee Meeting . . . . . P. W. THOMPSON 511

Charles J. Russell—Obituary 511

New Reports of Joint Subcommittee on Development and Research 512

Recent E.E.I. Publications 514

Refrigerator Sales, 480—Power Sales Items, 515
Conventions and Meetings, 516

EDISON ELECTRIC INSTITUTE

STATISTICAL DATA OF THE ELECTRIC LIGHT AND POWER INDUSTRY

Compiled Monthly by the Edison Electric Institute—Covers 100% of the Industry

DURING THE MONTH OF OCTOBER

	1936	1935	%
Kilowatt-hours Generated* (net)			
By Fuel	6,477,326,000	5,680,704,000	+14.0
By Water Power	3,083,996,000	2,595,117,000	+18.8
Total Kilowatt-hours Generated	9,561,322,000	8,275,821,000	+15.5
Additions to Supply			
Energy Purchased from Other Sources	166,809,000	174,694,000	− 4.5
Net International Imports	94,982,000	91,223,000	+ 4.1
Total	261,791,000	265,917,000	− 1.5
Deductions from Supply			
Energy Used in Electric Railway Departments	44,093,000	44,854,000	− 1.7
Energy Used in Electric and Other Departments	108,791,000	108,389,000	+ 0.4
Total	152,884,000	153,243,000	− 0.2
Total Energy for Distribution	**9,670,229,000**	**8,388,495,000**	**+15.3**
Energy Lost in Transmission, Distribution, Etc.	**1,577,040,000**	**1,565,053,000**	**+ 0.8**
Kilowatt-hours Sold to Ultimate Consumers	**8,093,189,000**	**6,823,442,000**	**+18.6**
Sales to Ultimate Consumers (kwhrs)			
Domestic Service	1,324,314,000	1,186,018,000	+11.7
Commercial—Small Light and Power (Retail)	1,421,076,000	1,220,241,000	+16.5
Commercial—Large Light and Power (Wholesale)	4,574,157,000	3,726,353,000	+22.8
Municipal Street Lighting	213,733,000	206,917,000	+ 3.3
Railroads—Street and Interurban	373,958,000	360,009,000	+ 3.9
Railroads—Electrified Steam	109,528,000	72,932,000	+50.2
Municipal and Miscellaneous	76,423,000	50,972,000	+49.9
Total Sales to Ultimate Consumers	8,093,189,000	6,823,442,000	+18.6
Total Revenue from Ultimate Consumers	$179,972,300	$162,788,900	+10.6

DURING TWELVE MONTHS ENDING OCTOBER 31st

Kilowatt-hours Generated* (net)			
By Fuel	66,999,872,000	54,239,222,000	+23.5
By Water Power	36,620,966,000	36,101,268,000	+ 1.4
Total Kilowatt-hours Generated	103,620,838,000	90,340,490,000	+14.7
Purchased Energy (net)	2,981,915,000	3,014,974,000	− 1.1
Energy Used in Electric Railway and Other Departments	1,936,819,000	1,954,521,000	− 0.9
Total Energy for Distribution	**104,665,934,000**	**91,400,943,000**	**+14.5**
Energy Lost in Transmission, Distribution, Etc.	**16,855,749,000**	**15,686,443,000**	**+ 7.5**
Kilowatt-hours Sold to Ultimate Consumers	**87,810,185,000**	**75,714,500,000**	**+16.0**
Total Revenue from Ultimate Consumers	**$2,045,410,300**	**$1,902,536,000**	**+ 7.5**
Important Factors			
Percent of Energy Generated by Water Power	35.3%	40.0%	
Domestic Service (Residential Use)			
Average Annual Consumption per Customer (kwhr)	714	663	+ 7.7
Average Revenue per kwhr (Cents)	4.78¢	5.09¢	− 6.1
Average Monthly Bill per Domestic Customer	$2.84	$2.81	+ 1.1

BASIC INFORMATION AS OF OCTOBER 31st

Generating Capacity (kw)—Steam	23,938,500	23,693,400	
—Water Power	9,318,100	9,283,800	
—Internal Combustion	634,800	610,300	
Total Generating Capacity in Kilowatts**	33,891,400	33,587,500	
Number of Customers			
Farms in Eastern Area (Included with Domestic)	(658,398)	(563,263)	
Farms in Western Area (Included with Commercial—Large)	(239,475)	(216,147)	
Domestic Service	21,628,391	20,955,421	
Commercial—Small Light and Power	3,800,202	3,780,127	
Commercial—Large Light and Power	515,903	512,564	
Other Ultimate Consumers	63,646	68,158	
Total Ultimate Consumers	26,008,142	25,316,270	

* By courtesy of the Federal Power Commission, with deductions for certain plants not considered electric light and power enterprises.
** New Series both years—Revised to agree with data contained in Statistical Bulletin No. 3, Statistical Department, December 15, 1936.

Vol. 4, No. 12, Edison Electric Institute Bulletin; published monthly. Entered as second-class matter Aug. 17, 1933, at the post office at **Philadelphia, Pa., under the act of March 3, 1879.** Publication office, 56th and Chestnut Sts., Philadelphia, Pa. Editorial office, 420 **Lexington Ave., New York, N. Y.** Subscription rate, $2.00 per year in the United States; $3.00 per year in foreign countries.
The Edison Electric Institute does not assume responsibility for, nor necessarily endorse or approve, statements made by contributors to the Bulletin.

EDISON ELECTRIC INSTITUTE BULLETIN

Volume IV DECEMBER, 1936 No. 12

Government Ownership: Theory vs. Experience

The Many Municipal Plants Established Represent the Triumph of Hope Over Experience—The Many Abandonments Are a Story of the Victory of Fact Over Theory

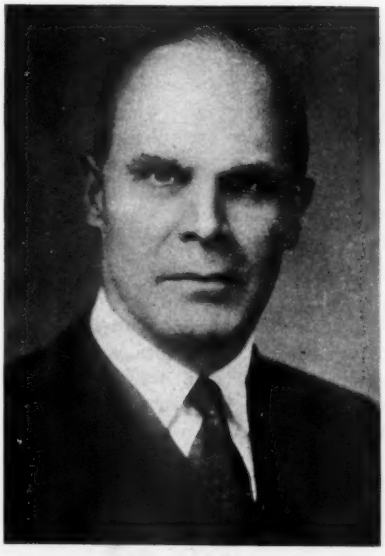
By C. W. Kellogg

President, Edison Electric Institute

A talk before the Investment Bankers Association Convention, Augusta, Ga.—December 5, 1936

THE question of whether a city or other governmental body should manufacture and sell the electricity supply for its citizens or leave that matter to a publicly regulated private company is a question of practical economics. With the passage of the years, however, it has become so encrusted with the barnacles of politics on the one hand and prejudice on the other, that it is most difficult to break through these encrustations and get down to the basic economics of the situation. One of the most obscuring of these barnacles is the habit of protagonists on both sides to use a few chosen isolated figures to prove their case. It was long ago observed that the "Devil can quote Scripture for his purpose"; i.e., he can utilize isolated sections of the Good Word to produce or forward evil; and similarly, by choosing your figures, you can conclusively prove either side of the government ownership controversy. I insist, therefore, that it is essential to stick to broad averages unless one's purpose is merely to nourish an already full-grown prejudice.

The public interest in the matter is plain and simple—the people want the best possible electric service at the lowest feasible cost. The verdict of 50 years' experience in this country is that this goal on the average can be best attained through private ownership and operation. I do not claim there never was an efficiently and honestly operated



MR. KELLOGG

municipal electric system, any more than I do that there never was a private electric plant stupidly and inefficiently managed (for I have seen examples of both), but on the average the private plant has proved more satisfactory.

To sketch the story very briefly in figures: In the beginning, in 1882, when the electric industry involved great risk and much experimentation for the investor in it, this risk was gladly left to private capital. As electricity became more generally used and known, city-owned plants sprang up, for reasons I shall explain later, and the high tide of municipal ownership was reached in 1902, over 30 years ago, when 9 per cent of all electric plant capacity in the country was municipally owned. After that the tide turned and by 1932 this percentage had dropped to 5 per cent of the total, and in that year 98.6 per cent of the electric power supplied to industry came from private plants. As to numbers, 75 per cent of the 421 municipal electric generating plants established in the decade from 1920 to 1930 had by 1932 been either sold to private interests or abandoned. During the entire history of the electric industry, going back over half a century, a total of 3938 municipal plants have been established, of which 2068 have been sold or abandoned. I shall try to analyze the reasons which have led to these results in the last 50 years. Two questions naturally arise: why have so many municipal plants been started and why have over half of them been given up?

The reasons for agitation for the establishment of a city electric plant are quite varied but the reasons for proceeding to the actual installation boil down to the apparent soundness of the theory back of municipal ownership. This theory is simply that electricity is a well-nigh universal need—therefore what more logical plan than for the people themselves, through their government, to own the facilities for its production

and distribution and sell it to themselves at cost?

The reason such a large proportion of municipal plants have been abandoned is that this alluring theory does not in practice produce that desideratum of the best possible service at the lowest feasible cost. The average experience over a long period of years in this country is that private enterprise can come nearest to reaching that desired end. In a word, the many municipal plants established represent the constant triumph of hope over experience and the many abandonments are a story of the victory of fact over theory. The reason that in many cases municipal plants continue to function is that the facts are obscured by various means.

One of these obscuring factors is taxes. It is perfectly clear that the net cost of its electricity to any community is the difference between the gross amount paid for it to the supplying company and the taxes paid by the company. Today 14 per cent of their gross receipts are paid in taxes by the private electric utilities, so that a true net cost of electricity to a given community from a private source is but 86 per cent of the apparent gross amount. Fair comparisons of average household rates charged respectively by private and municipal plants are difficult to arrive at because the larger proportion of the municipal plants are located in relatively low cost areas, thus showing a weighted average of 8 per cent* in favor of the municipal plants, but if compared State by State, the private plant rates are lower, except for small users of electricity. The average rate differences are not large one way or the other, but when the private plant rates are corrected for the 14 per cent tax burden they bear (from which in general the municipal plants are exempt), the private plants' rates are distinctly lower.

This allowance for the effect of taxes on net cost to the public is far from being the only factor obscuring the facts. In addition there are numerous expenses involved in municipal service which are not charged against that service but are paid by the taxpayers in other ways, such as office space in city buildings, legal advice from the city attorney's office, engineering from the city engineer's office, and so on.

*This was based on Federal Power Commission Rate Survey figures, representing conditions about two years ago. Subsequent rate reductions have wiped out even this figure in favor of municipal plants.

There are two other factors which cause the actual experience with municipal ownership to depart materially from the theory upon which such ownership is proposed, namely politics and financing.

The political angle presents the most curious paradox of the whole question, in that what its proponents put forward as municipal ownership's chief virtue proves in practice to be its worst vice. The argument runs that privately-owned utilities are, like any other private business, run for profit, while a governmental body, designed to furnish service at cost, can forego profits, which can thus be saved for the community served. This argument overlooks two fundamental points: first, with regard to utilities themselves, that the rates permitted by public regulation are only enough to pay for the cost of service, including a fair return on the investment; and second, that the very striving for profit produces an efficiency in the operating forces which in a governmentally-operated property is usually impossible to attain. By and large the employee of a private company must perform satisfactorily or lose his job, while in any public body political considerations carry the greater weight, not only as to the quality of individual performance, but also as to the number of persons employed, so that the fancied ability of the municipality to save profit is really the cause of much greater loss due to lowered efficiency.

You have before you today in the person of Mr. J. D. Ross one of the isolated cases I mentioned a few moments ago. He has given over 30 years of tireless and unselfish devotion to the public service of building up of the municipal electric system in Seattle. If his case were typical, the story of municipal ownership of electric utilities in our country in the last 30 years would probably not be one of continual decline as it has been on the whole during that period. James Bryce, writing 50 years ago, commented on the conspicuous failure of American city government to achieve economy and efficiency and basic conditions have changed little since then. Democratic freedom was never the handmaiden of economy; we are all convinced that our democracy is worth the price it costs, but in candor we must admit it is not a cheap price.

In the line of efficiency, one of the stock criticisms made by public ownership advocates of privately-owned and operated electric utilities is the alleged high salaries paid by private utilities compared to those paid by municipalities. Here also is a paradox for the uninformed. There is probably no business where errors in policy and design and planning can be more expensive than in the electric business. Capable brains and experience cannot be employed for small salaries, yet without such capability expensive mistakes cannot be avoided. The privately-owned companies spread their expert services over many properties, so that even the smallest get their benefit and thus obtain the most able advice on an economical basis. As a matter of fact, executive salaries form but 1 per cent to 2 per cent of the gross revenues of electric utilities and they range lower than in non-utility industries, like motors, steel, etc.

The other factor just mentioned wherein experience has failed to measure up to preconceived theory is finance. This is because the electric industry has always been a growing one and because it is such a glutton for capital. Every dollar of additional gross earnings of an electric utility requires $5 or $6 of new capital for generating plant and distribution facilities. With the relatively slow and rigid processes of city financing this new capital requirement presents a very difficult problem, not only in our own but in foreign countries. The inevitable effect of it is a curtailment of needed development, making service inadequate and therefore unsatisfactory. This difficulty has been one of the most common causes for the large number of abandonments or sales of municipal plants referred to earlier in this paper.

In connection with financing, the claim has been made by protagonists of municipal ownership that the city could raise capital more cheaply than the private company, and that this difference represented a substantial saving to the people. With the passage of time the credit standing of private utility securities has so much improved that the former advantage has either largely ceased to exist or has become a smaller factor. In general, it should be considered in connection with the basic question, which some even of our largest cities have had to face, of whether the excessive use of municipal credit for utilities does not both lower the credit rating of the city and also curtail the ability of the city to finance adequately its requirements for streets, schools and

other public needs which can be furnished only by the city. A city does, of course, possess the advantage over a private company of being able to issue tax-exempt securities. This apparent advantage, however, does not represent a net saving to the people because taxes must be collected somewhere.

Another point which municipal advocates have stressed is that the city retires its securities, while a private company does not. A moment's reflection will make it clear that the money required for retiring securities must come from the people and must to that extent increase the cost of the service. Private companies could similarly reduce their securities if allowed to do so by public regulatory bodies; but as the process requires higher rates, it has not been encouraged by such bodies. Tax-exemption alone, at present rates, would retire a utility completely in 35 years but the money for the purpose would have been paid by the people.

The private utilities have from time to time been bitterly criticised as being "vested interests" which through their monopoly gouge the public with high rates; and the intimation is advanced that this monopoly has been somehow grasped from an unsuspecting public. Such statements overlook the economics of the situation. The economic reason why the electric industry has to be a monopoly lies in the relatively high investment required. The average capital invested in all industry in this country, based on the last census figures, is 71 cents per dollar of annual gross revenue. In general industry, therefore, competition which is desirable in order to produce the greatest efficiency, does not affect a proportionately large investment of capital; or at least the relative amount of it is such that investors are frequently willing to risk it in a competitive enterprise. In the case of the electric industry, however, the capital required per dollar of annual gross is eight times as large as with industry as a whole, and such an amount of capital the investor dare not risk in a competitive enterprise. It is the realization of this unavoidable high investment ratio which has led to the standard practice of making the electric utilities a regulated monopoly—regulated so that no more than cost is charged for the service, a monopoly in order both to avoid the waste due to duplication of large investment, and, by thus protecting the investor, to induce him to invest his capital in such enterprises at the lowest feasible rate.

Up to the arrival of the New Deal the matter of governmental or private ownership and operation of electric utilities was largely a municipal question, but during the last few years the Federal Government has come into the picture in a big way. Before the recent developments the question before the body of citizens of any city was whether, with the various considerations previously mentioned, they believed they could get better and cheaper service from the municipality than from a private company. While there were some hidden subsidies of the nature above outlined, they were often not of great moment.

When the Federal Government got into the electric power business, the hidden subsidies, paid for with taxpayers' money, took on huge proportions. The form which these hidden subsidies took was to charge costs for both construction and operating expenses to other things than electricity. The most flagrant examples were found in the case of the Tennessee Valley Authority, the so-called TVA. The dams built by TVA in the Tennessee River or its subsidiaries were expected to improve navigation and help control floods. Obviously the more of their cost that could be charged to these other functions, the less there would be to charge to electric power, and hence the cheaper the power would seem to be—for 85 per cent of the cost of furnishing hydro-electric power is in the form of fixed charges on the investment. According to the last annual report of TVA (page 63, 1935 Report), of the total investment in programs of $48,487,500 only $3,142,500, or about 6½ per cent, was allocated to electricity. In the case of the Wilson Dam at Muscle Shoals, which cost $46,951,000, the U. S. Army Engineers reported that $37,000,000 (or 79 per cent) was chargeable to electric power, but the TVA, when given charge of this Muscle Shoals development, reduced the allocation to electricity to $19,529,000. This much lower amount is still over 41 per cent of the total investment and is six times as large as the per cent allocated to electricity in the other TVA activities.

A further measure of the inadequacy of the TVA cost allocations to electric power is obtained by comparing the dams on the Tennessee River which the TVA proposes to build at an estimated cost of $337,000,000* with the $75,000,000 which the U. S. Army Engineers estimated would be required to construct these dams for navigation purposes alone (House Document No. 38, Appropriation Committee 1936). On this basis the difference of $262,000,000 would represent electric power. This would require allocating about 78 per cent of the cost to electricity. Similarly, in the case of the Bonneville Dam, nearing completion by the U. S. Army Engineers Corps on the Columbia River, 40 miles above Portland, Ore., Col. Robins, in charge of the work, testified last May before a Congressional Committee that from his engineering analysis 69 per cent of the estimated cost of $65,000,000 was allocable to electricity.

The difference between the percentages allocated to electricity by expert engineers just cited and the 6½ per cent allocated by the TVA through its last report is the measure of Government subsidy to electricity.

So much for subsidy arising out of allocation of construction costs. In the matter of operating expenses, more hidden subsidies may be found. In the same 1935 Report of the TVA it is stated (page 33) that the seven small municipalities buying TVA power had made a satisfactory financial showing on the basis of retail rates lower even than such a city as Seattle; and to substantiate the claim the financial reports of these seven small plants are set forth on pages 73 to 76. Inspection of some of the figures shows how the subsidy worked. In the case of Tupelo, Mississippi (one of the seven towns), where during the year in question 731 major domestic appliances were sold and nearly 300 new customers obtained, the total commercial and new business expense was reported as $1,675—about the salary of one man. While Tupelo (a TVA customer) was thus claiming such low cost, the TVA itself in the same year, with Federal funds behind it, reported 154 persons on the payroll of the Division of Operation of its Mississippi Division, and carried over $100,000 for sales promotion work, part of which was available for Tupelo. The Electric Farm and Home Authority also spent in that year over $200,000 for promotional and educational programs. All of these form subsidies of very large proportions, much larger percentages than obtain with most city-owned plants, for all seven little city plants combined reported but $9,000

*From p. 279 Report of Hearings before Subcommittee of House Committee on Appropriations in March, 1936.

for commercial and new business expense. Total operating expenses, including taxes and depreciation, reported by Tupelo in its last report were only 24.5 per cent of the costs with a well-operated private plant with about the same number of customers.

TVA is thus another example of the contrast between theory and practice. When it was launched by the Federal Government, it was supposed to serve as a yardstick to measure the fairness of rates charged by privately-operated plants. In practice it seems to have become a yardstick for measuring the size of government subsidies directed against private business.

The TVA is far from being the only subsidy the Federal Government, in the newly adopted policy, has offered to municipalities for electric development. Through the PWA and the WPA the Federal Government has offered to municipalities throughout the country (and in many cases urged their acceptance) direct cash subsidies, first of 30 per cent and later of 45 per cent of the cost of construction of an electric plant to any city which desired to erect a municipal plant to compete with its private utility. It is interesting to record that in the case of scores of American cities even these excessive subsidies were insufficient to lure the electorates into voting for bonds to pay for the remaining 70 per cent to 55 per cent respectively. These subsidies were pure gifts with no interest charges or obligation ever to repay. Nothing would seem to show more clearly the desperately poor case for municipal ownership and operation of electric utilities than the fancied necessity for government to offer such huge subsidies for their support.

There are two other questions which these excessive Federal Government subsidies to governmental electric development naturally evoke:

1. On what theory should people in one city (through Federal taxes) be called upon to pay nearly half the cost of an electric plant in some other city?

2. What is the reason for such excessive governmental solicitude about electricity, which forms about 2 per cent of the wage earner's budget, where residence rates have been brought down almost continuously for the last 50 years (and are now but 60 per cent of what they were two decades ago) and when household electricity costs but one-fourteenth as much as the tax burden?

The recent incursions of the Federal Government into the electric field thus differ entirely from the oft-repeated ex-

(*Continued on page* 514)

SALES—ELECTRIC REFRIGERATORS

(*Household Models Only*)

MONTH OF OCTOBER AND FIRST TEN MONTHS OF 1936-1935

	Month of October 1936	Month of October 1935	Month of September 1936	First Ten Months 1936	First Ten Months 1935
Total United States	44,380	43,706	80,050	1,878,062	1,467,189
Maine	43	90	71	7,021	7,727
New Hampshire	214	76	267	6,184	5,571
Vermont	37	46	(74)	4,323	3,450
Massachusetts	1,499	1,845	3,594	72,824	61,441
Rhode Island	163	123	386	9,302	7,743
Connecticut	965	367	807	32,035	23,576
Total New England	2,921	2,547	5,051	131,689	109,508
New York	9,295	8,058	17,501	219,457	178,163
New Jersey	2,105	1,809	4,712	79,953	63,467
Pennsylvania	4,537	4,657	8,807	173,319	117,242
Total Middle Atlantic	15,937	14,524	31,020	472,729	358,872
Ohio	2,454	2,634	5,354	122,951	89,986
Indiana	924	728	1,567	52,937	37,674
Illinois	2,749	2,933	3,274	137,589	108,449
Michigan	1,759	1,663	3,706	92,064	61,874
Wisconsin	422	486	654	31,256	25,090
Total East North Central	8,308	8,444	14,555	436,797	323,073
Minnesota	596	342	608	26,064	21,150
Iowa	397	327	529	28,624	24,882
Missouri	470	553	2,269	59,008	44,850
North Dakota	(3)	35	59	2,915	4,039
South Dakota	64	85	(62)	4,818	5,179
Nebraska	55	177	176	16,213	16,405
Kansas	243	188	789	22,035	19,181
Total West North Central	1,822	1,707	4,368	159,677	135,686
Delaware	109	96	19	3,660	3,205
Maryland	521	451	907	20,599	21,430
District of Columbia	445	698	1,104	18,184	12,055
Virginia	442	465	1,203	29,587	21,810
West Virginia	95	197	193	23,262	15,781
North Carolina	296	429	554	35,561	25,756
South Carolina	189	243	260	17,337	12,873
Georgia	430	452	585	31,135	28,072
Florida	2,271	3,080	3,543	27,100	25,209
Total South Atlantic	4,798	6,111	8,368	206,425	166,191
Kentucky	375	308	257	25,042	17,147
Tennessee	685	400	1,277	28,914	25,059
Alabama	279	351	802	21,146	22,280
Mississippi	155	139	290	10,744	7,414
Total East South Central	1,494	1,198	2,626	85,846	71,900
Arkansas	67	4	298	10,938	10,267
Louisiana	668	498	1,144	19,336	14,624
Oklahoma	98	175	630	18,765	17,117
Texas	1,011	1,708	2,881	76,601	63,271
Total West South Central	1,844	2,385	4,953	125,640	105,279
Montana	56	63	260	8,764	6,367
Idaho	60	65	231	8,972	7,132
Wyoming	7	33	51	2,840	2,450
Colorado	129	232	662	13,731	11,778
New Mexico	16	48	135	3,683	3,312
Arizona	112	104	129	5,885	5,737
Utah	134	40	400	11,182	7,425
Nevada	93	44	182	2,760	1,847
Total Mountain	607	629	2,050	57,817	46,048
Washington	343	454	1,071	31,059	21,942
Oregon	205	243	500	19,567	14,629
California	6,101	5,464	5,488	150,816	114,061
Total Pacific	6,649	6,161	7,059	201,442	150,632

This summary includes adjustment figures reported by several companies which do not represent their actual October sales but are corrections to be applied to their first nine months totals to give their correct total apportionment among the various states for ten months.
(Figures based on report issued by the National Electrical Manufacturer's Association.)

Electric Power for the Farmer

By M. C. Burritt

Commissioner, New York State Public Service Commission

An Address before The New York State Farm Bureau Federation at Syracuse, N. Y., Nov. 11, 1936

WE have reached that period in our development in which available electric power is no longer regarded as a privilege for those farmers who can afford it, but as a necessity and a right for all farm homes and enterprises whose nature and location are such as reasonably to guarantee their stability and permanency. This right differs from that of rural free delivery, for example, chiefly in that private enterprise necessarily attaches certain conditions of reasonableness based on sound economics, whereas the government places no such limitation as to whether or not the service rendered will pay its cost. This difference arises not only because private enterprise must always count the cost while government is not required to do so, but on the important fact that large and semi-permanent local investments not easily removable are required to serve electricity, whereas no such investments are imposed by mail delivery. This condition will at once raise the question in some minds, "Why not have government ownership and universal distribution of electric power, instead of limiting it largely to private enterprise?"

We have all been much interested of late in having electric lines extended to serve the 60 per cent of our farmers not now served, and this is very important. I shall have more to say about it later. It is really equally important to consider by what system, or under what state policy, all of our farms are to be served. These policies are likely to be formulated in the not distant future. Some are already taking shape. Can farmers be best served by regulated private companies, or by municipally owned plants? Is a state subsidy necessary or desirable? First without taking sides on this important question, recently much in the public eye, I would like to summarize for you the present state of facts regarding public and private ownership of electric public utilities in New York State, and point out their relative advantages and disadvantages, with especial reference to rural areas; and then perhaps to express an opinion.

Regulated Monopolies and Municipal Ownership

First, to avoid confusion and to confine myself to actual rather than theoretical or propaganda discussion, let me define what I am talking about. There are two systems or means of providing electric central station current, both adopted state policy, and both legally and definitely provided for under New York law.

The Public Service Law, since modified in several important respects in its essential outline, was first enacted in 1907 upon the recommendation of then Governor, now United States Chief Justice, Charles Evans Hughes. In principle it recognizes public utilities as essentially monopolies and outside the field of ordinary direct competition (which does not mean that they have no competition), and therefore subject to complete regulation and the necessary supervision by the State as to their properties and general policies. This means that their territory is limited to that specifically franchised and certificated by the localities and the State, that their standards of services, the value of their properties, their earnings thereon and the rates to be charged their consumers for service, are subject to the State's approval and may be modified by it. Likewise, they must keep their books, records and accounts as prescribed, make reports which must be available for public inspection as required, and they can issue no securities of any kind without state approval. In short, *if effectively regulated* by the Commission, to which the administration of law is delegated, they are really the agents of the State to furnish service as required at approved rates, subject only to the constitutional rights of persons and corporations.

By public or municipal ownership and operation of electric utilities I mean the furnishing of electric service directly by the State or one of its authorized subdivisions, which owns at least the facilities of distribution and which may also provide the sources of power and its transmission. This state has had provision for such ownership and operation since 1897 when general permissive legislation was adopted providing for village electric systems. Even prior to this there may have been some special charters and special laws. These provisions for municipal ownership were enlarged and further defined by laws adopted in 1934 (Chapters 281 and 285). Certain regulation of municipal rates and service are reserved by the State to be exercised by its agent, the Public Service Commission.

Under this municipal legislation 52 municipalities in the state serve approximately 75,000 customers. Jamestown with 15,000 consumers is the largest, and Deering Harbor, with 24 customers, is the smallest of these. Others furnishing electric service are Dunkirk, Westfield, Arcade, Penn Yan, Marathon, Ilion, Hamilton, Boonville, Richmondville, Rouses Point and Freeport.

Outside of New York City (which has six electric companies with 2,000,000 customers), there are 66 private electric utilities in the state serving 1,450,000 customers. Of these seven are affiliated with the Associated Gas and Electric System and nineteen with the Niagara Hudson System, leaving forty not affiliated with these two large holding company systems.

It is of interest to note that of a total of about 61,500 farmers receiving central electric station service in the state in 1935 only about 500, or less than one per cent, were served by municipalities. This number constituted only 0.7 of one per cent of the total customers served by municipalities. It is obvious that municipal service is almost wholly urban—city or village.

From the above it is apparent that electric service in New York is predominantly provided by private regulated utilities who serve 95 out of every one hundred electric customers (this does not include New York City, where private companies serve almost 100 per cent).

The Cost of Electric Service

There has been so much misunder-

standing as to the cost of electric service that it seems desirable to discuss the elements that enter into costs briefly, in order to fairly consider the possibilities of reducing them either under regulation or municipal ownership. If one system generally produces lower costs than the other, then, other things being equal, I should prefer it. There is nothing sacred about either system. We all want what best serves the public interest.

For our purposes here all costs may be considered in four principal groups:

1. Production
2. Transmission
3. Distribution
4. General, including overheads and administration

Let us look into each of these briefly.

Production. Electricity may be and is obtained, whether by a private utility or by a municipality, in one of three ways: (1) by outright purchase from another company, (2) by generation in its own steam plant, and (3) by hydro generation by its own water powers. Municipalities and the smaller private companies generally purchase their power at the most favorable rate they can bargain for, which is usually less than they can generate their own. Within reasonable limits, the larger the generating facilities the cheaper an efficient plant can produce current. In any case production costs are one of the smallest elements of cost—generally from 2 or 3 mills to one cent per kwhr at the bus bar, dependent chiefly on the amount taken and its distribution over the 24-hour period, or load factor.

The economies of state or other municipal over private production of electric current are not readily apparent. Cost of electric current is not a function of ownership but of location, natural advantages, size, efficiency of generating facilities, and other such factors, whether privately or publicly owned.

Transmission costs are also a function of distance rather than ownership. Hydro power is frequently at long distances from the centers of consumption, e.g., the St. Lawrence. Where it is near, transmission costs are low and current likely to be cheap, e.g., the Niagara Frontier, where rates are the lowest in the state.

Steam generated electric power is usually cheapest where the plants are located on tide water, because of the cheap transportation of coal, e.g., New York City.

Transmission involves rights of way, poles or towers, wires, labor, line losses, etc., whether owned by a private company or by the state or a subdivision, and there is no reason to believe that the one can transmit electricity any more cheaply than the other.

Distribution presents much the same problem. Poles, wires, transformers, labor, services, meters, etc., account for the principal elements of cost. How can a city or a village distribute the juice more or less cheaply than a private company, given reasonable efficiency? The answer is, it cannot.

General Overhead and Administrative Costs. It is here that such differences as exist in favor of municipalities are most readily apparent. Private companies in the past have had a tendency to pay much larger salaries to their officials, to add larger overheads, sometimes theoretical and more or less non-existent, than the municipalities; to erect expensive office buildings, pay higher rents, memberships in public organizations from Chambers of Commerce (and Farm Bureaus) to golf clubs, contributions to charity, and now, old age security, pensions, and all the rest. All these add cost to a kilowatthour not usually experienced, at least to the same degree, by municipalities. But a more realistic management and efficient regulation are eliminating many of these.

The municipal plant may or may not pay any taxes. Unpaid bills of municipal customers are a lien against the taxpayers' property and these costs may be less. Street lighting may not be paid for on the basis of costs. These and other minor factors must also be considered.

The Public Service Commission in the famous Boonville case pointed out one way to reduce municipal costs below those of private companies. It suggested and ordered that when the bonds to build the plant had been retired out of earnings, that the municipality should not charge or collect any further return on the capital paid for by consumers, thus thereafter avoiding a five or six per cent return on such fixed capital as a profit. But the municipalities themselves opposed this, took the matter to the courts and secured a reversal of the Commission's order and established the same legal basis for municipal rates as those of private companies. To my mind that is not only inequitable, but foolish and retrogressive.

A good test of private versus municipal ownership as a measure of low rates is the comparison of rates actually charged in the state today. The rates are hard to compare, for many reasons, some of which I have discussed. Some municipal rates are lower, notably those of Jamestown and Penn Yan. These two serve comparatively few farms. Many are higher than those of neighboring private companies. Generally, municipal rates appear to be lower for small consumptions, but higher than private company rates for larger customers.

Some Further Aspects of Private vs. Municipal Ownership

There are other considerations to be kept in mind in formulating a public policy which will secure the widest distribution of electricity at the lowest possible rates. Among these are (1) the character and location of the municipal unit or the private company and the territory served, (2) the efficiency of the municipality or private company, and (3) the freedom of these from political control in the one case and from domination by a holding company on the other.

The tendency of private companies has been distinctly toward consolidation and centralized control. The proof of this in New York is that about 75 per cent of the territory of the state, outside of New York City, is served by one of the two great systems, viz., the Niagara-Hudson, and the Associated Gas and Electric. The companies which make up these systems do not always serve integrated and logically connected contiguous territory. Some serve cities, chiefly, e.g., Buffalo and Elmira. Others serve chiefly rural areas, with few cities in their territories, which are widely scattered, e.g., Niagara, Lockport and Ontario Power Company and the New York State Electric & Gas Corporation. Most of the companies would be willing to correct these conditions, and the Commission would probably favor some reorganization under proper conditions. To my mind, the ideal situation would be to have the logical trading territory contiguous to an urban center with which it has many common trade, distribution and other interests served by the same company with the same basic rates, modified only to provide for minimum bills and rates in the first blocks of energy sufficient to offset the lesser densities of customers. Such situations are approximated at such centers as Rochester, Albany, Binghamton and Hudson, and to a less extent in the Syracuse and Utica territories.

Municipal plants generally tend to confine their services to cities and vil-

lages. Out of 52 in the state only nine serve rural areas, except purely incidentally, and these provide only a minimum of farm service. There is not a single instance of a municipal plant in the state which serves adequately the entire adjacent territory which could most logically be served by it. Arcade and Westfield probably come the nearest to this. No rural territory is itself organized for municipal service. Usually, and with few exceptions, the small number of rural towns served by municipal plants are served incidentally and at rates generally higher (by ½c to 1c per kwhr) than in the municipality itself.

In a few cases where municipalities do not serve electricity outside their boundaries they sell to local associations or corporations, as, for example, Skaneateles, which sells current to one such line at 3c per kwhr, the owners of the line maintaining it and bearing all the additional costs. This is expensive and unsatisfactory to rural areas.

If municipally owned and operated plants should continue to develop along present lines we might eventually have a situation in which the cities and villages would be serving themselves, with the rural areas largely left to the private companies, which, having lost the densely populated areas, would likely find it difficult to make ends meet. Farmers and other dwellers in the country would then find themselves obliged to pay higher rates, or, as is the case in the Province of Ontario now, electric service would have to be directly subsidized by the state to provide comparable rates.

The efficiency of a plant is determined first by factors inherent in its set-up, such as location, size, the demands for service, unavoidable costs, etc., and secondly, by management. While it is not necessarily a fact, even within reasonable limits, that the larger the plant the lower the costs, other factors being equal, this is likely to be true. It is certainly true that some private companies and many municipal plants are too small, and their loads too poorly distributed to be as efficient as larger plants with more diversified territories. It is a fact also that size makes possible the employment of expert engineers, accountants, management and rate men, which gives the companies able to employ them a considerable advantage. It is true, too, that many municipal plants lack such experts and suffer therefrom.

One other factor merits consideration. We are just emerging from an age of over-organization, combinations, centralization, and domination of private utilities from the top by holding companies. In many cases these have milked the local operating companies, not only by taking out excessive dividends, but also by overhead service charges of many kinds and out of proportion to the benefits received. This unhappy period has probably passed, thanks to drastic legislation, both state and federal, and such overhead domination is not likely to be longer dangerous to the public interest.

Municipalities are of course free from such conditions, but they are subject to another danger equally ominous, viz., political control. The politicians have long since discovered that a municipal plant may be made a handsome source of revenue—some of which may come from farmers—which can be used to keep down the tax rate by diverting it from the rate payer. Such diversion keeps up the electric rate, takes money from the rate payer and gives it to the taxpayer, not always the same parties and usually in a different ratio. This is indirect taxation, usually inequitable, and may lead to serious abuses.

My experience is that municipal plants need rigid supervision by the state fully as much as the private companies. Their accounting is often very poor, their engineering not always the best, and their managements too often underpaid and politically controlled.

There are, of course, other factors, such as sources of power, distribution of loads, interchange of power between companies, etc., which have a bearing on any complete evaluation of municipal versus private ownership as a method of electric service. Time does not permit the discussion of these here.

Effective Regulation

Personally, I believe that the private ownership of public utilities, *providing they are effectively controlled and regulated,* is likely to provide the best service at the lowest rates, unless municipal plants are to be heavily subsidized by government. *This is particularly true of service to farmers,* for the reasons already stated, and especially because rural areas by their nature are more difficult to organize for municipal service.

At the same time I believe that it is good state policy to have the provision in law which we have in New York, which authorizes municipal service if and when private service and rates prove to be unsatisfactory to the public. When utilities are unreasonable in resisting regulation or arbitrary in their service and rates, or if the regulatory body is ineffective or negligent, the possibility as well as the fact of municipal ownership is a threat to make the bad boys less exacting and more reasonable.

The first essential of good regulation is the disposition to make it fully effective and to really control the utilities in the public interest. While we have not always had this disposition in the past, we do have it now, on the part of the legislative body, the Governor, and the immediately responsible body, the Public Service Commission.

Secondly, the necessary authority must be embodied in law. The Public Service Law of New York, originally conceived by Governor Hughes, has long been an effective instrument of regulation. It had its weaknesses of omission, soon discovered by smart lawyers paid to do so. Recently, most of these weaknesses have been remedied and the gaps stopped, so that now most of the necessary means of effective regulation are provided.

But laws must be constitutional and questions of constitutionality are the subject of much dispute. Particularly have the companies invoked those provisions of our constitutions which provide that the property of any citizen shall not be taken without due process of law. The law is not always equitable, and some decisions of the Commission designed to interpret the law equitably to consumers have been reversed by the courts after long litigation. In some instances the law has been changed by the legislature, and in spite of long, hard fights by utility lawyers, often over highly technical points, the law as interpreted by the courts is gradually being tightened so that control of public utilities by state and nation, backed up by the threat of municipal competition, is now in a fair way to become completely effective.

One further essential to effective regulation is the personnel of the regulatory body and its attitude toward regulation. As to this we will let a former member of the Commission, later its Counsel for 15 years, recently resigned to take up private practice, speak. General Blakeslee has had a long experience and ample opportunity to observe. Recently he said:*

"I argue that the policy of the Public Service Commission, as now constituted, has become progressive; it certainly is realistic. We have no feigned, imaginary, negative or indeterminate attitude of public interest. The Commission, broadly speaking, views it-

*From an address before the 31st Annual Convention of the Empire State Gas & Electric Assn., at Saranac Lake, N. Y., Oct. 1, 1936.

self as being, not the representative of utilities, nor particularly concerned with security holders (except to the extent of seeing to it that all securities issued are backed by 100 per cent of tangible property; coupled with as low a return as the Commission can effecuate), but as directly and positively representing one group, the rate-payers."

* * *

"So far as utilities of New York State are concerned, such a policy is extremely fortunate. Complaisant regulation would be fatal today. A strong commission—actively bent on protecting every right or privilege of the rate-payer—is the most effective and soundest bulwark against public ownership, and against remote control regulation, that the gas and electric industry of this state could have, even if it took counsel and could choose its own means of self-protection.

"Why do I say this? Because we have an intelligent and progressively minded regulatory body, with every facility for prompt, efficacious and just presentation and determination of all questions of rates, service and financing, actively favoring the consumer's interest. Is there anything in any scheme of public ownership or operation which can do as much? If there is any such provision written into any plan of public operation for the consumer's benefit, I have never seen it."

Progress in Rural Electrification

Before closing this discussion I should like to report to you the status of rural electrification up to date, and to call your attention to some important considerations affecting its future. I last reported on this at the annual meeting of the State Agricultural Society in Albany last January. Since then progress has not only been steady but has acquired momentum.

The reports of the companies to the Commission indicate that about 4000 additional farmers and approximately 7200 rural but non-farm customers were added to rural lines during the first six months of 1936. This involved the construction of 1425 miles of new lines calling for an expenditure of about two and one-quarter million dollars to give service to about 6100 customers. The other 5100 new customers were given service from already existing lines.

Reports are not yet available, of course, for the last six months of 1936, but our information indicates that construction will approximately equal that of the first six months. It is safe to say, therefore, that during 1936 approximately 3000 miles of new rural line will have been constructed, to add about 11,000 new customers on new lines, of which about 6500 are farmers, bringing the total New York farms served by central station electric current to 70,000. This is about 40 per cent of all our farms, as recorded by the 1935 census, and compares with about 58,000 farms, or 33 per cent, served a little more than a year ago.

Obviously, farms cannot be electrified without the cooperation of prospective customers. Neither the companies, the Commission, nor the farm organizations can bring about electrification unless the individual customer wants and is able to take the service. Some evidence that he has not always done so in the past is the fact that in 1936 nearly 10,000 customers (two times the first six months, 5000) were connected, not to the new lines built this year, but to previously existing lines. This number is comparable with the 11,000 added to new lines, showing that almost as many new customers already had service available as were added by the building of new lines. This is not pointed out critically, because I know that many farmers were unable to do what they wanted to do even when an electric line went right by their farm. But it is a fact, and this inability to take service has made it impracticable to build other lines.

One of the most irritating situations now developing in connection with rural extensions is the refusal on the part of a certain few property owners to give rights of way. Under the new plans generally in effect, and at the instance of the Commission, the companies must hold their costs of construction to the lowest possible figure if they hope to approach anything like a reasonable return on their rural lines. This means that they should, where practicable, be permitted to build their lines where they will have the least tree interference and where they can take the greatest advantage of topography in lengthening spans. I am not unmindful of the inconvenience and undesirability of having lines cross fields. I merely call attention to the other side, another aspect of the question.

If we are to keep the investments in rural lines down, rights of way at least along highways should be given freely. Not to do so may defer the building of the line indefinitely. If condemnation proceedings are resorted to, costs are greatly increased. Payments for rights of way only add to costs, which it is very desirable to keep down.

In closing I want to again call attention to a very important factor which I stressed at Albany in January. The minimum guarantees now required by the companies in some rural areas probably initially produce income not much greater and perhaps in some cases not as great as the out-of-pocket costs, not including general overheads, depreciation and return. The profitableness, even the existence of the line, is therefore almost wholly dependent on increased use by existing customers, plus a few additional users. In the same way the full value of electric service to farmers can only be realized through the use of all the appliances which are economical or which bring large added convenience and satisfaction.

Not only is this true, but the maintenance of existing rural rates, and further reductions in these rates, is absolutely dependent upon increased volume of use—load.

With the continuing reduction in residential rates which are generally applicable in rural territories, the customers must use a larger number of kilowatthours if the revenue is to approach the amounts which would have resulted before the rate reduction. For this reason, if rural electrification is to be successful, current must be used liberally by the customers.

If the rural lines do not yield the companies a return adequate at least to pay costs if not a profit, one of two things must happen. Either the urban centers must carry the load by making up the deficiency, or rates must be increased. Neither is to be desired. City consumers may not long consent to the former, and the latter would tend to defeat its own ends. Substantial increases in use is the best—indeed the only satisfactory answer to the problem.

The Farm, Light and Power Committee, which has done such good work in promoting electrification, should now, in my opinion, concentrate its efforts on building up an adequate use of that which it has helped so much to make available. Without such increased use we may lose much of what has been gained. Further progress in rural electrification depends a good deal on the intelligent and full use of facilities now available and upon the building of line loads, sufficient not only to support the lines already built but to warrant the building of more lines and further reductions in rates. The companies have come through with a necessary program for line extensions at reduced rates. It is now distinctly up to the rural users to say whether they will make sufficient use of the facilities built to warrant the present and future investments.

The Case Against Government Monopoly of Electric Power

By Frank A. Newton

The Commonwealth & Southern Corporation

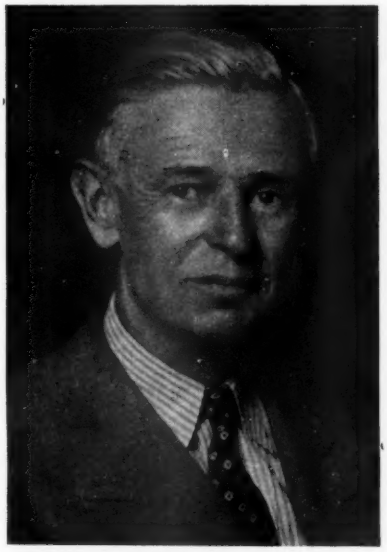
This is the negative side of a debate at Purdue University, Lafayette, Ind., Dec. 5, on the proposition: Resolved: That all Electric Utilities Should Be Governmentally Owned. Mr. W. I. Nichols, Director, Division of Electrical Development, Tennessee Valley Authority, championed the affirmative side, substituting for Dr. A. E. Morgan of TVA.

I HOPE what I may have to say may not be too largely a repetition of what you have heard heretofore in the debates on this subject. There are many issues involved in this question. There are many points which might be discussed. The limited time at my disposal prevents any complete discussion of all the various phases of this subject. It is my purpose to confine myself to certain features which are not ordinarily given much consideration in a discussion of this question but which are entitled to very serious attention. Also I would like to emphasize what to me appear to be the most vital questions involved in this matter of public ownership of all electric utilities.

At the outset and with no intention to quibble or to inject technicalities into this debate, I feel that it is proper to call attention to just what the question means. The question reads: "Resolved: That *All* Electric Utilities Should Be Governmentally Owned and Operated." This is not a question of whether municipal ownership has been a success or not in isolated instances. It is not a question whether it is proper or not to establish rate "yardsticks" by the government. It is not a question of the success or failure of partial public ownership in Ontario, or Sweden, or any other country.

This is a question of complete government monopoly, a question of whether or not public ownership and operation of all electric utilities in the country is necessary or desirable.

I am not contending that every publicly owned electric utility in the country should be displaced by private ownership. That is not the question before us. The affirmative of this question, however, must prove that every private utility should be displaced by public ownership. Despite the fact that there are well known outstanding cases of privately owned electric utilities in this country with the most splendid public relations, furnishing the most efficient service to the public and at rates exceptionally low, conservatively capitalized and against which even the most ardent public ownership advocate can direct no criticism, despite that fact the affirmative of this question has the burden of proving that even those companies must be displaced by public ownership.



MR. NEWTON

Those who contend for a complete government monopoly and rely upon facts derived from municipal or government operations in other places, must, of necessity, demonstrate that the conditions under which such successes were obtained—if they were successes—prevail throughout the United States. Reference is made to the Ontario Hydro Electric System. That is not complete government ownership. Canada has 11 provinces and outside of the single Province of Ontario, privately owned utilities generate 94 per cent of the total power supply. Again the Ontario Hydro System has been operated at a very serious deficit for several years, as their reports disclose. Sweden, which is pointed to as an example of the success of public ownership, does not have complete government monopoly nor is it the expressed intention of that government to bring about public ownership of all electric utilities.

It does not meet the issue involved here, as I see it, to assert that public ownership is coming, that it is inevitable and that the tendency is in that direction. I dispute the accuracy of this statement. I do not believe the American public wants a complete government monopoly of the electric utility business now or any time, but that is beside the point. To say that government ownership may or should be brought about 10, 15, or 20 years from now is too indefinite and too remote a proposition to be given serious consideration in a discussion of that problem at this time. Conditions 10, 15, or 20 years from now may be so different from what they are today that the entire question will need different consideration under an entirely different set of circumstances. There is only one fair construction to be placed on the question at issue and that is, should there be complete government ownership and operation, a complete government monopoly of all the electric utilities in the United States as conditions now exist or as they may reasonably be anticipated in the near future.

Municipal Ownership

During the 54-year history of the electric utility industry in the United States and while electric service has been brought to practically every hamlet, village and city, public ownership has had ample opportunity to demonstrate its efficiency and its advantages. The greatest number of municipal electric utilities

in existence at one time was 3077 in the year 1923. In 9 years that number had declined to 1849. A total of nearly 4000 municipal electric systems have been established at one time or another since 1882. Of this number 2068 have been sold or abandoned. Municipal ownership has been tried in nearly 4000 communities. Less than 1900 municipal systems remain and half of these do not generate their own power but buy it from private companies. Today, after years of experience and despite the arguments of the advocates of public ownership, only 6.4 per cent of the electricity used by the customers of this country is sold by municipally owned plants.

Municipal ownership has failed, after 54 years, to convince the people of the United States that it is necessary or desirable. Not only has municipal ownership been unsuccessful in fact but it is wrong in principle. As has been pointed out by Mr. Arthur E. Morgan (Chairman of the T.V.A.), "Electric power distribution by public ownership must be seen as a regional rather than as a municipal matter." Again quoting from Mr. Morgan, "For electrical distribution, a city is not as a rule a normal unit."

This brings us to the inevitable conclusion that if we are to have a complete government monopoly of the electric utility industry, it must be, as Mr. Morgan has pointed out, through regional systems. It must spread over areas embracing not only many cities and communities but even a number of neighboring states, all under the direction and control of some central bureau in Washington which shall control the destinies of the country as far as the supply of electricity and its price are concerned. The result would be the greatest political organization ever known to the world, controlling the location of power plants and transmission systems, fixing the price of power to industries, as well as to the homes, directing the location of industries and influencing votes through its expenditures for plants and by the rates it charges. Imagine such an organization spreading over the whole country and reaching into 21,000,000 homes.

That it would be possible to bring the various states together under federal control for the generation and distribution of electricity is but wishful thinking. It is simple to state but difficult, if not impossible, to bring about. There are many legal difficulties in the way, as well as practical political difficulties.

Look at the situation with reference to the matter of traffic laws, divorce laws, corporation laws, highway construction and numerous other matters. Have the states acted in unity or uniformity? Different states in different sections under different conditions have varying views on these questions. Which is right? Who knows? Shall rigid uniformity be forced upon them regardless of their convictions and their local conditions? The states have been jealous of their rights and privileges and they will continue to be so. It will be difficult to convince states with large water powers and other states with great coal mines that their advantages should be shared equally with others.

Another matter which will impose great obstacles to such a plan will be the problems created by the loss of taxing power by the states. By public ownership properties will be removed from the tax rolls and the tax revenues lost by the change from private to public operation must be passed on to the other taxpayers.

Past Abuses

Much is said by those who contend for government monopoly of the electric utility business about alleged abuses and mistakes which have been made in the past in the industry. Yes, mistakes have been made under private ownership, but let us remember that it is easy from the safe vantage point of the side lines to point out the mistakes made by those who must make decisions and act in the midst of the game. After the game is over, there are many Sunday quarterbacks who could have done a much better job.

Those who have never had to soil their hands with actual work in shop or field, those who have not been compelled to spend sleepless nights worrying and planning how to develop new and greater business, build new plants and raise the money for such undertaking, those who have had none of these trying experiences always find it easy to point out mistakes and indicate a remedy. Certainly, however, there is nothing in the record of politics and in the abuses and mistakes of those in public office, local, state or federal, which would lead any thinking person to believe that political domination of the industry would be preferable. It seems to me that in continually bringing up the name of some past utility executive who may have violated his trust, using that as an argument for complete governmental monopoly, is about as logical as to insist that because men in public office and high places have at various times violated their public duties, that is a reason why the offices so violated should be abolished.

The abuses so often referred to have been almost entirely corrected or eliminated. Such legislation as may still be necessary to remove remaining abuses is favored by an overwhelming percentage of the electric utility industry.

The loyal officers and employees who have built up the electric utility industry of this country and those who are now furnishing a service which is unparalleled in the history of the world, in economy, efficiency and high standard of service, are but human beings, honestly trying, proud of their record and hoping of course to pass on through efficiency and loyalty to greater responsibilities and greater rewards. They owe their positions, not to any political representative, but to their own accomplishments.

Let those who base their contentions for government ownership on the mistakes which have been made in this industry under private operation demonstrate that the record of government in business has been of such character as would lead to higher standards, greater efficiency and great loyalty in the conduct of this tremendous industry. Mr. Thomas A. Edison well said: "There is far more danger in public monopoly than there is in private monopoly."

Regulation and Government Monopoly

Under our American system, a large and responsible place is given to government in the field of business. It is given the function of regulating business in the interest of freedom, fair play and the general welfare. Regulation is a judicial function and properly belongs to government. The states for a number of years have regulated the electric utilities as to their rates, as to the service they furnish to the public and as to the issuance of their securities. That regulation has been effected by means of boards or commissions upon which the legislatures have bestowed authority to regulate the utilities within the boundaries of the respective states.

Those who contend for complete and unregulated government monopoly of the electric utility industry must show that the public interest will be better served under such a system than under the present system of private management under public regulation. The question is not whether the present system is perfect, but whether the alternative of complete unregulated government monopoly under political control is better.

Those who contend for a government

monopoly of the electric utility industry assert that state regulation has failed. Those who favor complete unregulated government monopoly realize that state regulation must be discredited before they can convince the public that government ownership is either advisable or necessary. Let there be no misunderstanding. Public ownership displaces regulation. Public ownership and regulation cannot get along together. It must be one or the other; witness the fact that the TVA has refused to acknowledge the jurisdiction of the state regulatory commissions in those states in which it operates. With but few exceptions municipally owned and operated electric utilities are exempt from the regulation of the state commission. Municipal plants have always fought against state regulation.

Those who insist that state regulation has failed and that it must be supplanted by government ownership and operation have much to explain away in the history of this industry. The electric utility industry in this country represents an investment by the public of over $13,000,000,000, the greater part of which has been put into the business under state regulation. Electric service has been brought to every community in the United States of over 1000 population, also to over 33,000 villages of less than 1000 population, of which 20,000 are hamlets with less than 250 inhabitants. There is hardly a hamlet without the convenience and comfort of electric service. This has been accomplished coincident with the growth and development of state regulation. The rates charged to customers have been reduced steadily throughout the history of the industry until today they are at their lowest level. Since 1913, the use of electricity in the American home has almost trebled, but the cost per kilowatthour has been reduced 42 per cent. State regulated utility rates fell during the last 10 years at a more rapid rate than the composite of all unregulated items comprising the cost of living and rates are still falling, while at the same time the unregulated items of household expense are either rising or standing still. This too has been accomplished under state regulation, and in the face of a mounting cost of government and in the face of constantly rising utility taxes.

Some of the commissions are understaffed, some of them need more extensive powers. All of these are matters readily taken care of by the legislatures of the various states. Complete, orderly, impartial, yet strict state regulation, together with private ownership and initiative, has proved itself. The record is there for anyone to see. The progress and development of the electric utility industry of this country is the envy of every country in the world.

The 1937
E.E.I. CONVENTION
will be held in Chicago,
June 2-4, inclusive.
Details in later issues.

It has always seemed to me that the position taken by these advocates of public ownership that state regulation has failed puts them in a most absurd and inconsistent position. How do they expect that if government has failed to regulate successfully as they say that it may be expected to operate successfully? This is contrary to the old principle that he who is faithful and efficient in smaller things may be expected to be faithful and efficient in larger things. Those who contend that public ownership is necessary because state regulation has failed would seem to reverse the Biblical principle and hold that he who is faithless in smaller things committed to his hands should therefore be given greater responsibility and made ruler over bigger things.

Industry and Electric Power

Electric power is a vital factor in manufacturing and in industry in general. Yet this fact is seldom mentioned in these discussions and given little or no consideration. The reason for this is obvious. Practically all arguments for government ownership are directed to its assumed social advantages and to its claimed benefits to the domestic customer. Why is this so? The answer is that at the end of 1935 there were over 20,779,000 domestic users of electricity in the United States, while there were at the same time but 504,000 industrial customers of the electric utilities. In these nearly 21,000,000 homes live the voters of the country to whom the appeal for public ownership is directed.

Let us look at a few facts as to the sale of electric power in this country. In 1935, out of a total sale of electricity of 77,555,000,000 kilowatthours to all classes of users, the domestic customers used but 13,978,000,000 kilowatthours, or 18 per cent. During the same year the industrial customers used 41,162,000,000 kilowatthours, or 53 per cent of the total sales. The remainder went to the small commercial light and power customers, for street lighting, to electric railways and municipal buildings. Many electric utilities sell over 60 per cent of their output to industrial customers, the percentage running as high as 70 per cent in some cases.

This tremendous volume of industrial sales of electricity by the electric utilities of the country has made possible the development of more efficient steam turbines and steam generating plants and the building of large hydro-electric undertakings. This is the class of load which has been responsible for long distance transmission of power and the interconnection of great utility systems. It is this industrial business of the utilities which by reason of its great volume of use and good load factor, has made possible the present low level of domestic rates.

The electric utility industry is differentiated from other industries by the fact that fixed charges constitute such a large part of its total cost of operation. The investment required in an electric utility is generally from 5 to 7 times its annual gross revenue. Or, to put it in another way, it turns over its capital but once in from 5 to 7 years. The ordinary mercantile or industrial enterprise turns over its capital often, many of them several times a year, few requiring more than one or two years. Volume is therefore of vital importance in the business of generating and delivery of electricity. Unit costs and the price per kilowatthour depend directly upon volume of output. When one factory purchases at one point as much power in one year as 100,000 domestic customers for whose service millions of dollars are required in poles, lines, transformers and meters and for whom 100,000 meters must be read and 100,000 bills computed, delivered and collected every month, it is realized what part industrial sales play in electric utility engineering, investment and operation and in the ultimate cost to the customers. This is an actual case. There are others like it.

Let me make clear at this point that this large industrial business of the electric utilities pays its way. The carrying of this industrial load by the utilities puts no burden on the domestic customers. On the contrary, this large scale industrial business, this generation and delivery of power in great blocks, has reduced unit costs, has improved efficiencies of operation and has brought about, more than any other factor, the

constant reduction in domestic rates throughout the history of the industry to a present level lower than ever before. On this I speak from over 25 years' experience in cost analysis and rate-making and with no fear of contradiction.

Now the power to dominate and control American industry through governmental ownership of the electric utility industry is a most dangerous power to put into the hands of any government. With such power, government could easily penalize certain sections of the country and certain industries and reward other sections and other industries. No American loyal to our constitutional freedom wants any such power and no group of radicals should ever be permitted to have and exercise such power over American business. At this point let me repeat the words of Mr. William Green, President of the American Federation of Labor:

"Analysis of the industrial situation shows that electric power is the greatest contributing factor toward the increase in the efficiency and productivity of the working people in our country.

"Both employers and employes in America have been free from the domination of autocratic control and governmental dictation such as prevails in some of the lands.... Let us hope our nation will always remain free from governmental autocracy and dictatorial control of its industries and workers."

What may be expected to happen if the electric industry comes under complete government ownership and operation? Can't you see the inevitable wire pulling and log rolling between different states and different sections of the country to secure and to hold industries? Can't you see the same thing will come about which has always prevailed in the building of roads, river and harbor work, the location of the post offices and in all governmental undertakings? The large industrial power users under government ownership would not be dealing with private companies at arms' length, on a sound economic basis, but would be compelled to deal through political representatives in Washington in order to protect their rates and their supply of power. They will be forced to resort to political influence to protect themselves and their workers and their communities or build and operate their own plants.

If these industrials are thus compelled to build their own power plants, that volume of sales would be lost to the governmentally owned and operated electric power plants, unit costs will rise and higher rates to the residential and commercial customers will be required or larger deficits incurred to be made up by the taxpayers.

Is this fear of what will happen to the industry under government ownership and operation of the electric utilities a mere fancy? Let us see what has happened in the Ontario Hydro Electric System, the largest governmentally owned and operated electric utility in the world.

In that system, the residential customers receive rates materially lower than the commercial customers and the ordinary power users who use electricity in much greater quantities. Political pressure reduces the rate to the domestic customers and holds it up for the commercial and industrial users. What do we find with respect to the Tennessee Valley Authority? First, and of great significance, we find that the Act under which the TVA was created provides that in the sale of power first consideration must be given to the residential and rural customers. Commercial and industrial customers are to be given secondary consideration. We find in the last published bulletin of the TVA that the average rate paid by the commercial customers in the localities it supplies and under the rates it dictates is 25 per cent higher than the average rate paid by the domestic customers, even in the face of the fact that the commercial customers use two and one-half times as many kilowatthours per year.

Under the present system of private ownership and operation, there is always present possible competition of publicly owned plants. Yardsticks may be set up, as in the case of the TVA, to measure the reasonableness of the rates of the privately owned system. In other words, there is always open an alternative to private ownership, namely, public ownership and operation. If a municipality is convinced that economies can be effected and other advantages obtained by changing from private to public operation, it may always do so. But once complete, unregulated government monopoly of the electric utility industry is effected, there will be no alternative.

There is no magic in government operation. Under any government monopoly the utilities would still be operated by human beings, subject to the same emotions and weaknesses, with no greater abilities than those operating the private utilities. Workers in government as in private undertakings wish to hold their jobs. The difference is that under government operation the individual worker is too often judged by his political belief or influence rather than by the test of efficiency in the performance of his duties.

The dangers of government monopoly were seen and expressed by Mr. Arthur E. Morgan when he said:

"The success of public ownership will extend only so far as it can be divorced from political patronage. . . . If we greatly increase public ownership, then the doctrine that 'to the victor belong the spoils' will spell the doom of social and economic decency and health."

Cost of Government

Let us turn for a moment to the record of the privately owned electric utility industry in this country and contrast it with the record of government. In the year 1935, the average family in the United States paid $33.82 for all the electricity it used—an average of 9c per day. At the same time the cost of government, federal, state and local, was over $480 per family, 14 times the cost of all domestic use of electricity. A reduction of only 10 per cent in the cost of government would pay the entire domestic electric bill of the country and leave over $14 per family to be spent or saved. Since 1913, the average cost of domestic electricity has been reduced 42 per cent. No extravagant statement that the rates charged by the electric utility are excessive and unreasonable can be justified by the facts. There is no business about which the public, through its agencies, knows so much. The electric utility industry has been operating in the gold fish bowl. The state commissions have literally taken the utilities apart many times to determine what their costs are, whether they are proper costs and the relation of these costs to the rates charged.

The American family today buys nothing of equal value and convenience as cheaply as it buys electricity. It has been pointed out that the tax alone on 1½ packages of cigarettes per day is greater than the cost of domestic electricity. The automobile users of this country pay in taxes, alone, $100,000,000 a year more than is paid for all domestic electricity. The fact is that domestic electricity is cheap. It is difficult to see what justification there is for all this agitation by politicians and others about the cost of electricity which amounts to only 9c per day per average family. What is all the shouting about? Here is a commodity, if you please, the price of which has been reduced faster than any other commodity. Here is a commodity, the cost of which has steadily declined while the cost of living and

the cost of all other commodities have advanced.

Perhaps the reason for all this agitation lies in the fact that the industry has 25,000,000 customers and serves over 21,000,000 homes and farms, in which millions of voters live.

It should be noted that the standard governing the furnishing of electricity throughout the country under state regulation is practically uniform, so that customers may move from a hamlet to the largest city or from one section of the country to another, finding service of the same standards and the same character and able to use the same electric appliances. It is also significant to note that there is a growing tendency for uniformity of rates regardless of size of the locality served. This is in marked contrast with the situation in Ontario. What this means I may emphasize when I point out that the Commonwealth & Southern System, which I represent, through its various operating companies in 11 states, was serving at the end of 1935 nearly 3000 communities with an average population of but 1800. Yet these companies, with few exceptions, charge the same rates in all of the communities they serve with no regard to their size or location.

TVA and the Yardstick

With reference to the TVA and yardstick it has set up, I think no more complete, no fairer statement can be made than was made by its Chairman, Mr. Morgan, in the *Forum* magazine when he said:

"The President wishes that somewhere in America there should be a case of public generation, distribution and sale of power. He is of the opinion that power developed in this country ought not everywhere to be a public project, that private development of power has decided advantages and ought not to be abandoned. But he feels there ought to be here and there cases of public ownership which can serve as comparisons. And if they are to serve as comparisons, they must be open and aboveboard with nothing hidden. They must be fair, with no special, arbitrary advantages. They must pay taxes, just as private utility companies must do, and every other reasonable charge, if they are to provide us with a fair comparison."

With a yardstick so conceived and so applied there can be no complaint and at the same time private ownership would have no fear.

You, who will within a few years be ready to go into some profession or some business activity, have, I am sure, two objectives in mind. First, in whatever you may do you will seek to excel in

(*Continued on page* 514)

Handbooks for the High School Debates

A NUMBER of handbooks and manuals have been prepared by various agencies for the use of participants in the 1936-1937 high school debate on the proposition "Resolved, That all electric utilities should be governmentally owned and operated." This debate subject was chosen by the National University Extension Association for high school and college students, after debating leagues throughout the nation had expressed their choice. This year's debate is the tenth in a series that have been sponsored by the Association, and it is expected that more than 100,000 students will participate.

The handbooks that have been issued so far include the following:

National University Extension Association

ELECTRIC UTILITIES — Tenth Annual Debate Handbook 1936-7. Volume I—edited by Bower Aly, Assistant Professor of English, The University of Missouri. Published by arrangement with National University Extension Association. Lucas Brothers, Columbia, Mo. 1936. 220 pages—single copies 75 cents.

ELECTRIC UTILITIES — Tenth Annual Debate Handbook 1936-7. Volume II (as above) Lucas Brothers, Columbia, Mo. 1936. 220 pages—single copies 75 cents.

Platform News Publishing Company

GOVERNMENT OWNERSHIP OF ELECTRIC UTILITIES—J. Weston Walch, Chief Compiler. 174 pages, 8⅜ x 10¾. Platform News Publishing Company, 45a Free Street, Portland, Me. 1936. $2.50.

A PRACTICAL GUIDE TO REBUTTALS —Frank A. Allen, Platform News Publishing Company. 1936. Single copies $1.25.

SUPPLEMENTARY REBUTTAL NOTES —Platform News Publishing Company. 1936. Price $2.00. Issued four times during debate season.

PLATFORM NEWS—Platform News Publishing Company. 50 cents per year. Issued monthly and contains articles by leading authorities on both sides of question.

STUDENT'S PROBLEM BOOK ON ELECTRIC UTILITIES—By J. Weston Walch. Platform News Publishing Company. 1936. 21 pages. Single copies 25 cents.

E. C. Buehler

SHOULD THE GOVERNMENT OWN AND OPERATE ELECTRIC UTILITIES?—Compiled and Edited by E. C. Buehler, Director of Forensics, University of Kansas. Noble and Noble, Publishers, Inc., 100 Fifth Avenue, New York City. 350 pages, $2.00.

H. W. Wilson Company

GOVERNMENT OWNERSHIP OF ELECTRIC UTILITIES—Compiled by Julia E. Johnsen. The Reference Shelf, Volume 10, No. 9—H. W. Wilson Company, 958 University Avenue, New York City. 1936. 329 pages, 90 cents.

Congressional Digest

GOVERNMENT OWNERSHIP OF ELECTRIC UTILITIES—PRO AND CON—Congressional Digest, 2131 LeRoy Place, Washington, D. C. October, 1936, issue. 32 pages. Single copies 50 cents.

American Federation of Investors

DEBATER'S HANDBOOK — Presenting Arguments Against Government Ownership and Operation of Electric Utilities—Prepared by C. C. Carrothers, A.M., Debate Coach—Drake University. American Federation of Investors, Inc., 35 East Wacker Drive, Chicago, Ill. 1936. 63 pages. Single copies 25 cents.

Public Service Magazine

THE CASE AGAINST GOVERNMENT OWNERSHIP — Edited by Robert C. Clemnison. Harvey J. Gonden, 35 East Wacker Drive, Chicago, Ill. 1936. 96 pages, 8 x 11.

Wisconsin Utilities Association

PRIVATE OWNERSHIP AND OPERATION OF ELECTRIC UTILITIES—Wisconsin Utilities Association, 135 West Wells Street, Milwaukee, Wis. 1936. 144 pages, 10 cents.

Oklahoma Gas and Electric Company

MUNICIPAL OWNERSHIP IN OKLAHOMA—Oklahoma Gas and Electric Company, Oklahoma City. 1936. 27 pages.

The *Rotarian* for December, 1936, contains a short article for public ownership of electric utilities by Dr. John Bauer and a short article by Mr. C. W. Kellogg against such ownership.

The *Platform News,* published monthly by the Platform News Publishing Company of Portland, Maine, contains in its September issue an article by Mr. Carl D. Thompson entitled "Public Ownership of Electric Utilities Is Necessary." The October issue contains a reply to this article by Mr. Frank A. Newton. The November issue carries an answer to Mr. Newton's argument by Mr. J. D. Ross, and the December issue or January issue will contain a counter reply by Mr. Bernard F. Weadock.

Reference material on the negative side of the debate question was also prepared by the Edison Electric Institute at the request of the National University Extension Association. This material was discussed in the September issue of the E.E.I. BULLETIN.

Planning For Emergency System Operation

The load dispatching or system operating organization is the heart of a power system, particularly during periods of emergency. The ability of this organization to function successfully in the handling of major emergencies and to work toward restoring the system to normal operation depends to a large extent on an advanced and detailed study of the functioning of these men. Such a study should cover whether the organization has been made adequate, whether it is trained for its tasks and whether it has been furnished proper and sufficient facilities to meet the tests of these emergencies when they suddenly arise. The damage done by the floods last Spring in the mid-Atlantic and New England states with recent sleet and bad wind storms have emphasized the need of study how best to guard systems from these major troubles. The operation of a system during such emergencies is logically a part of such studies.

By Wm. R. Hamilton

Superintendent of System Operation, West Penn Power Company

Presented before The Fall Meeting of the System Operators of New England at Northampton, Mass., October 23, 1936

SYSTEM OPERATION can be classified into three major activities. These are:

1. Allocation of the load among the various power stations, arranging of the exchange of power over the various interconnections and arranging that adequate capacity for the system load will be on the lines.
2. Planning and arranging all outages on lines and equipment and supervising the switching for these outages to safeguard all employees working on or near circuits normally energized.
3. Directing the operation of all stations insofar as they affect service to customers or the system as a whole during any emergency which arises.

Considerable has been written, both for our trade publications and for presentation to E.E.I. and sectional committees on the first two of these subjects. The third subject, however, has had but little discussion and this has been confined to the events covering some outstanding case of trouble.

There has been an opinion that no specific guide for future conduct could be derived from studying the troubles of others because of the peculiarities in layout of different systems and because each emergency is different in development and in effect. Most operating men know now that they can profit by studying these troubles and experiences, even though the conditions have to be altered to fit their own systems.

Emergencies can be broken into two classes. These are emergencies of short duration, for example, those being confined within a period of 24 hours, and those of longer duration and extending over more than one heavy load period. By far the greatest number of troubles

MR. HAMILTON

are of short duration insofar as system conditions are concerned. This covers practically all lightning storms which are vicious in the mid-Atlantic area, practically all equipment failures such as the failure at Hellgate Station in New York and the bushing failures in Philadelphia a few years ago.

Emergencies of long duration occur rarely. Some systems have not experienced such troubles in recent years. The leading examples of major troubles are hurricanes sweeping up the Atlantic coast, tornadoes in the South and West, sleet storms on both sides of the Allegheny mountains, strikes such as the one at Toledo, serious power station fires, and floods such as those which have occurred in New England, the mid-Atlantic states and in the upper Ohio and lower Mississippi River basins.

These emergencies may cover the entire system, only a part of the system, or may only involve a company because of trouble on an adjacent system.

Planning system operation to meet adequately all of these different conditions would be an impossible task, for nobody can plan in detail all the needs of any system. In general, if you work to offset the worst conditions and events you have reason to expect, your company will be fortified against the lesser emergencies. You may not be justified in attempting to protect against troubles which are going to happen only once every few score years, so it is necessary that each review his problems, discuss the value of different plans and do the best he can with reasonable economy. The next disaster may come from an altogether different source.

The operating picture during these emergencies can be broken up into the problems of organization, communication, power supply, interconnections, system layout, station design and customer contacts. Several of these divisions overlap and are only touched upon in this discussion.

Planning an Organization

One important step in preparing for the handling of major emergencies by a system operating organization is the careful selection and thorough training of those men who will be on the firing line. Until a few years ago troubles were so frequent that the obtaining of ample experience in the handling of trouble was only a routine. The men

selected for this work were picked because they had courage, good voice and a good operating background. Usually their educational attainment was not high and they did not have much knowledge of the theory pertaining to the various troubles they were handling.

As equipment design has improved, and as the systems have become strengthened with more sources of power to each important area, the number of major emergencies has grown less and less. In order to keep up with the advancement in the quality of equipment on the system (it also becoming more complex), many companies are now selecting for dispatchers men with a better technical background and with ability to think their way through the troubles they experience. Nevertheless, these men are not obtaining sufficient experience in handling major emergencies. Methods must be worked out to give these men the necessary operating background to carry their systems without help through at least the first part of a serious emergency. To date very little material discussing satisfactory ways to carry out this training is available.

It is necessary that these men be kept thoroughly familiar with the systems they are dispatching. Such knowledge cannot be obtained from blueprints and maps. An organization should be large enough to permit these men to make frequent inspection trips over the system to study the equipment on the ground and even more important to know personally the men they contact over the telephones. Each organization should see that these inspection trips are made, and ascertain that the men obtain value from them. Trips at least once a month should be arranged. One good plan is to require each load dispatcher to write a report of each trip, and to offer in these reports constructive suggestions pertaining to the stations and the lines they examine. Many good ideas will come from such reports.

Frequent group meetings among the dispatchers is a fundamental part of any training program. These meetings have an increased value if specialists from other departments and organizations will discuss various problems in which the dispatchers are interested. It appears desirable to plan group meetings about once a month. The group meetings should be held away from the dispatching center when the study is to cover some problem that can best be studied elsewhere.

Successful operation of a power system depends as much on having capable well-trained operators as having capable load dispatchers. One operator in a self-imposed jam can cause the load dispatcher more worry, and can do more damage to the service than a good sized storm. The Philadelphia Electric Co. has done more toward an intelligent selection of their operators by carefully worked out psychological tests than most other companies. Their work on this subject is worthy of study.

It is West Penn Power Company's practice to furnish every substation with a complete set of emergency operating instructions and to give each station operator sufficient authority to restore all service in his station and to furnish service to adjacent stations without any load distpatcher's assistance, so if all communication facilities from the load dispatchers fail, power will continue to flow over all essential lines by the action of these operators alone. This plan has been so successful over a number of years that it is considered one of the reasons for the company's good operating record. It also is a basic aid in decentralizing the organization in a major emergency so that each unit will function on its own and handle its own troubles with very little outside help.

Many companies have recognized the need for and written an operating manual to assist in the training of their operators and load dispatchers. There are two objections to these manuals: first, the care and time required to write them and in keeping them up to date; second, the objection to giving the operating men this vast amount of material with the expectation that they learn it.

Actually each operator is expected to know practically all of the material pertaining to his job even though no manual is issued. Those who have issued such manuals have found them of definite value as a place for confining all active operating instructions. When such a manual is not often used operating orders are found to be in effect and in station files which were out of date and should have been recalled. The manual prevents this happening. One should recognize that these manuals are but references for spare time study for the older men, but they are very valuable as a guide for training new men.

The fact that Detroit Edison, Consumers Power, Philadelphia Electric, Public Service of New Jersey, Duquesne Light, Pennsylvania Power & Light, West Penn Power and many other companies have prepared such manuals indicates a definite value in this work.

Obviously it does little good to write instructions for operators unless there is a competent organization continuously active in training theses operators, reviewing the instructions with them, and rewriting instructions as changes occur. There is no man who is more likely to go stale and careless than an operator in a small station where trouble seldom occurs and where no one ever visits.

Organization Activity During an Emergency

There are two distinct types of emergency organizations to set up during these catastrophes. The first is that which has to operate the system. The second is that which has to restore equipment to service and to rebuild the property which has been damaged or destroyed. Usually system operating organizations are well trained and well manned so they need little assistance. Outside untrained help is only a hindrance and there should be no hesitation to refuse such help when ample trained men are available.

When a catastrophe comes over a large spread out system generally the troubles can best be handled by an organization so decentralized that each trouble center and each major unit in these centers will be under the supervision of someone with sufficient authority to act without hindrance. These units need tie into the central organization only when their activities affect system operation, or when they need additional materials or men. It is desirable, though, that these trouble units do contact with headquarters frequently to keep the management and the operating organization informed of progress. It is good practice to move one or two trained load dispatchers into the trouble areas to work closer with the emergency crews and to hold the contacts with the central organization.

Attempts will be made to contact department heads in these trouble areas for decisions on other matters. Such calls should be intercepted as much as possible for generally these decisions can be made by others less busy. They only require the approval of someone in authority.

On most widely spread systems, the System Operating Department, because of its trained personnel, accustomed to supervisory duties and being on duty twenty-four hours with the best of communication facilities available, can best

act as the contact agents between the areas in trouble and our officers. This department can act as a clearing house to expedite men and materials where they are most needed. It may find itself invaluable in locating and dispatching to the trouble areas every male employe who can help in the rebuilding. It is important, though, that one relay engineer be kept in close contact with the load dispatchers to study the system relaying as the operating setup is altered to meet the troubles being experienced.

No one man is big enough to direct alone a large organization through any catastrophe. Of course, department lines are forgotten. All operating men are accustomed to stay on the job 24 to 40 hours when major troubles occur. Such a practice is in order when the disturbance will clear up within that time, but when the catastrophe is one that will last for several days, these long sieges without sleep only impair one's general efficiency and may bring a relapse later. Company officers may have to insist that some leaders knock off for sleep after say the first 40 hours. Most of us pride ourselves in our ability to stand these long sieges, but actually we do so at only a sacrifice in efficiency. This may be only 50 per cent normal after the first 24 hours. The desire to be on the job should be weighed against our possible need later, when we may have to sleep. A schedule should be worked out as quickly as possible which limits the working hours of every man to 12 or 14 hours a day.

The Purchasing and Stores Departments should set up emergency organizations, available for 24 hour duty, to handle the ordering, and delivery of emergency materials as the calls come in from the trouble areas. These organizations must work closely with the organization contacting the trouble areas, that there will not be duplication of effort and so that when delays in delivery of supplies occur substitutes can be offered.

Layout of Load Dispatcher's Office

Many companies have located their load dispatching centers in substations or adjacent to control rooms in power stations. This was done because these were the most economical locations and because it was thought that the closer contact with the operating conditions at these more important stations would give the load dispatcher a quicker and more complete picture of what was happening.

Experience has shown that the load dispatchers tend to magnify the trouble at these stations in relation to the effect on the system as a whole. Often when serious trouble occurs at these stations the load dispatchers are so upset emotionally that their ability to analyze what is happening and their effectiveness in restoring the system to normal is impaired. Wherever possible load dispatchers should be located in quiet rooms, not necessarily remote from power and substations, but at least isolated from the sound and sight of any equipment with which they are concerned.

When planning a system operating organization with load dispatching centers which will function best during an emergency, each company has to decide whether a centralized plan or a decentralized plan of dispatching will function best.

The centralized plan seems to be favored for metropolitan systems, but both plans are used by transmission type companies. Generally if a system can be broken up into definite units of load, each with fairly well defined area, a dispatching center for each area is in order. Likewise, there appear to be definite limits in the distance or territory a dispatching center can cover efficiently without building an excessively elaborate telephone system. Modern thought seems to favor the decentralized plan of dispatching on an extensive transmission system rather than a larger organization concentrated at one location. Pennsylvania Power & Light, West Penn Power and the American Gas & Electric systems are three good examples of the decentralized plan of dispatching. Each method has its advantages and the geographical conditions of the system being served are the guiding factors governing which method is best applicable.

The reliability of a load dispatching center in maintaining contact with its system depends entirely on the telephone lines extending from it. Regardless of the care taken in safeguarding this telephone service, during extreme emergencies some or all of these telephone lines may be lost. In the case of a centralized dispatching system, this means complete loss of supervision of the entire system. In the case of the decentralized plan, it may mean only the loss of supervision over one area which can be supplemented by help from other districts.

When the commercial telephone companies are depended on for telephone service one is justified in arranging for two separate storm-proof cables connecting the telephone exchange to the load dispatching centers and important stations. Preferably each cable should come over a different route. If these cables extend through areas where possible floods can occur, the cables serving the load dispatchers should be free from all other taps through the flood area.

One important and expensive tool used by the load dispatcher is his telephone switchboard or turret. Every company has a different idea of how they should be designed. Some prefer keys for switching because of their compactness. These keys are mounted flat in the desk on a sloping faced panel or on a vertical panel. Another group objects to the keys and prefers cords because of the greater safety from exposed telephone circuits. Sometimes these telephone switchboards are built singly and sometimes mounted in units of two or more positions. Usually they are built so the load dispatcher can see over their top, but this is not always done. Generally they are designed to give more writing space than is obtainable on the standard telephone switchboard.

This lack of standardization requires separate development costs for every switchboard built. If the turret is furnished by the Telephone Company a high installation charge and possibly a high rental is necessary, for the Telephone Company recognizes there is little opportunity of using this design in any other place. The A. T. & T. Company, based on a questionnaire from many electric utilities, designed what the composite opinion considered an ideal load dispatching turret. Installation of this ideal turret necessarily carries such a high installation and rental charge that it is hard to justify in small dispatching centers.

It has been found that standard telephone switchboards can be used with complete satisfaction to meet all load dispatching requirements, with a resulting big saving compared to these specially designed turrets. At small dispatching centers and substations the key type switchboard holding up to 20 lines can be set on a standard flat top desk at an angle of 45 degrees to the right or left of the load dispatcher or operator to give him more writing space than he has when using the special turrets, and also giving him better vision forward. A cord type switchboard holding up to 80 lines can be mounted in the same position by cutting the desk so that the switchboard can be inserted. Three such

cord type boards in multiple are being installed in this manner in a new load dispatcher's office at the Springdale Power Station. The load dispatchers have stated they will prefer the new layout to the present switchboards being discarded.

Although only one or two men are required to handle dispatching requirements during normal conditions and most small emergencies, a major emergency requires more men on the job. The number of trained dispatchers who can work during these major emergencies is limited usually by the amount of telephone facilities available. Although the power system may logically break up into several geographical areas, often complete telephone facilities are furnished only two men. It seems essential that a load dispatcher's office be provided with sufficient telephone facilities that several dispatchers can work efficiently during emergencies without confusion and interference with each other.

Load Dispatching centers must be furnished with emergency lighting so that these men can work when there is a power outage. The capacity of such lighting should be adequate if allowance is made for adequate lighting when power stations are shut down.

The system diagram, the availability of records used during trouble and the application of voice recording all come within the scope of this paper, but these discussions are omitted from this paper.

Communication Problems

The need of communication between operating centers during any calamity is vital. Communication systems should be analyzed to protect the service from failure at such times, as much as this is possible, then if they do fail plans should provide auxiliary channels.

A transmission system because of its wide extent usually affords protection from total shutdown except in local areas. However, certain calamities such as floods, earthquakes and severe sleet storms may sweep down everything in their path. Many transmission and communication lines will go down during such disturbances regardless of the nature of their construction and regardless of their ownership.

Radio amateurs can be of valuable help in reaching isolated and stricken areas during such calamities. Radio amateurs, though, are not usually located where they are wanted and their contacts are not sufficiently reliable except as a back-up when all other means of communication fail. Nevertheless, power companies should inform themselves of the abilities of these amateurs to help when their help is needed and begin to pave the way by friendly contacts in advance so that this help will be extended willingly. Only those amateurs having an independent source of supply can be helpful during power outages.

Most of these amateurs are glad to help during these emergencies. The supporting of some of their competitions makes them even more willing to help when help is wanted. One company locates and contacts practically all of the active amateurs over its system about once a year, usually every winter. It lists these stations on a map and furnishes each amateur a copy. During the winter these amateurs usually stage some competition among themselves, with the power company contributing one of the prizes. This year, for example, they were offered the selection of an I.E.S lamp as a prize for a competition they are staging over the winter months. Note that these amateurs stage their own competitions. The only active part the power company plays is through a few of its employees who have licensed amateur stations. A licensed employee directs our contacts with this organization.

The Federal Communications Commission has so restricted our use of radio as an emergency source of communication that most companies believed the installation of company owned transmitting stations was not justified. The recent flood brings forward again the need of having one or more radio channels allocated to utilities for emergency use, and to modify the licensing requirements of transmitting stations maintained by utilities for use during emergencies. Recent discussions before the Commission may result in broadening this restriction as to hours of normal operation and frequency. A decision in the matter is anticipated in the near future.

At the present time the Lines Department of one company is experimenting quietly on a method of two-way station to truck communication by combining carrier current and radio. This promises to be reasonably successful. They have communicated successfully to cars near the distribution lines, the 25 Kv. and the 132 Kv. lines, from one fixed station. To date only the radio interference cars have been used in this work. The work of one company on the Pacific Coast in developing directional short wave communication is also worthy of study.

Of the four major plans of communication used by power companies, radio, carrier current, privately owned lines and leased lines, there is no question but radio functions best during these extreme emergencies. Carrier current will, of course, continue to operate until the transmission lines fail and this is a probability. Open wire circuits of the Telephone Company fail before our own open wire circuits necessarily because of differences in their construction, but cable circuits have proved themselves more reliable. No single method or plan of communication should be relied upon 100 per cent. Development of the possibilities of all methods should be encouraged.

Planning a Communication System

Communication lines of power companies should be so laid out and routines so set up that any lines of value to the dispatchers will be available to them quickly in an emergency. This does not mean that such lines be held continuously for operation, or that they must terminate at operating centers. The wide extent of the West Penn System necessitates a large number of non-operating calls over the Company's telephone lines. This used to necessitate considerable telephone switching by the station operators and load dispatchers. By using Bell Telephone facilities between substations and local offices, many of these lines are now terminated at certain offices during office hours and daytime calls between these offices are switched by the telephone operators. The substation operators still hold authority over these lines and all employees are required to give them up immediately upon request when the load dispatchers need them. The lines are not commandeered for routing operating calls and are only taken in a hurry when serious emergencies occur.

There seem to be two schools of thought in the relative value of a privately owned communication system and a communication system which depends largely or entirely on the facilities of the commercial communication company.

One group favors the development of their company's communication needs wherever possible by building an extensive privately owned communication system. Fitting into this plan are telephone lines constructed on our transmission and distribution pole lines, possibly privately owned cable lines in metropolitan

areas, carrier current circuits on transmission tower lines and a limited use of space radio. The Duquesne Light and American Gas & Electric Companies are two good examples. This group does not favor utilizing commercial telephone facilities in developing the power company's communication needs for numerous reasons which would be worthy of study.

The second group accepts the policy that power companies are not in the communication business and the services and facilities of the communication company should be utilized wherever possible, substituting privately owned facilities only where such substitution is more economical or more reliable, thus combining the two systems to give the most economical, reliable and flexible system that can be obtained.

This group recognizes that there are many problems pertaining to the services furnished by the telephone companies which still need to be solved. It recognizes that most of the claims of those power companies who favor owning their communication facilities, against the communication companies were true a few years ago and possibly are still true in some areas. Much progress, though, has been made during the past few years toward reaching an agreeable understanding on most of these controversial issues, as the engineers of both companies, where the two companies are working together, have a better understanding of the other company's problems than they had a few years ago.

Most communication companies now recognize the need of special requirements in Power Company service and are meeting these requirements. An example of this is the establishing of the term "public utility emergency," by the Bell Telephone Co. of Penna. for emergency calls made over their lines. When this phrase is used on any call, the operator's traffic instructions require her to use every possible effort to complete the call as quickly as possible, by re-routing toll calls any way to get through, by giving the call priority during traffic jams. She will even go in on a busy line to tell the persons conversing that a "public utility emergency" call wants the line.

The term is also used to request telephone and line repairs during nights and on holidays. Naturally the Telephone Company should not be required to maintain all power company telephones during these unusual hours, so the Power Company designates to the Telephone Company at the time of any trouble whether the trouble requires "public utility emergency" repair. The problem of maintaining such equipment during severe emergencies is one which justifies more study by the Telephone Companies. However, progress will continue to be made on these problems where the Power Companies and Telephone Companies are working closely together.

Last Spring's flood showed that telephone cables properly laid out and pressure tested annually would withstand being submerged. Of forty-two cables the Bell had under water in Pittsburgh they lost only three, and they lost these only because the terminals on taps from these cables were under water and water leaked back through the taps into the main cable.

Reliable communication should be obtained in cable circuits regardless of whether the Power Company or the Telephone Company owns them. The Telephone Company should be able to do the better job, though, in maintaining and safeguarding our service, provided the problem has been thoroughly reviewed and engineered by both companies, for this is their specialized field. The Telephone Company is better able to substitute other wire pairs when leased lines go bad. Also they can import skilled men from other areas not affected to help out. During catastrophes we may need all of our men to maintain our power system, and our problem is simplified if our communication needs can be maintained by the Bell. There is danger that some Bell employees may not give the need of power company service during the emergencies the same value we would our own lines and care must be taken to prevent careless loss of circuits or service delays.

When engineering a telephone system to work with Bell circuits under calamity conditions, three things should be recognized.

1. The Telephone Company exchange may lose its battery supply and be forced to pull the heat coils on all unessential phones to conserve their batteries. This will disconnect all of the phones not on their calamity lists.

2. The telephone exchange may go completely dead so all exchange lines will be dead and only magneto tie lines will continue working with local battery supply or hand generators.

3. The public telephone traffic may become so heavy at automatic and manual exchanges that delays on exchange calls will be experienced. Leased circuits are a safeguard against this.

The following questions are worthy of investigation by those companies dependent on Bell service.

1. Are your terminals and all terminals on the Telephone Company cables serving you high above any possible flood stage? The headquarters building of the West Penn Power Co. is in the Pittsburgh flood area, and the first floor contained 10 feet of water last March. Because the telephone cables serving this building became soaked from taps at other buildings the Telephone Company, during the Summer, brought two 100 pair cables, each over a different route, right to the telephone exchange on our 12th floor. Each cable is free from taps to other customers.

2. Do you have more than one cable routing and entrance to all your important operating centers? As Springdale Power Station will soon be dependent largely on Bell service, a second Bell cable is being brought to the station through the coal mine tunnel from the opposite side of the river.

3. Do you have facilities for maintaining stand-by battery service at your important common battery switchboards so that when all unessential extensions are cut off ample battery supply is available? The Bell batteries in our Pittsburgh office were not watched during last Spring's flood as carefully as they should have been.

4. Do you have hand generators at your switchboards that are capable of ringing on all tie lines should the battery supply fail? We found upon inspection that some of our hand generators were only 3-bar generators. All have now been changed to 5-bar generators.

5. Does the Telephone Company have all essential company and employee resident numbers on their respective calamity lists? We have been preparing a card index during the Summer to make available an easily changed list for Telephone Company use.

6. Are all company lines properly marked as essential on the Telephone Company frames at the heat coils and every other place where they can be opened? This is important to check for tie lines, signal and supervisory circuits, trunk lines and all other lines you want on their calamity lists. If this is not done the unmarked circuits may be lost any time the heat coils have to be pulled. Some Bell companies list these emergency lines on the proper subscriber line cards, but do not identify all of these circuits at the frames.

7. Are you assured 24-hour maintenance on your essential commercial Telephone Company lines without having to contact department heads? These arrangements are essential if service is to be maintained when emergencies are taxing the organization of the Telephone Company to keep their facilities in repair.

8. Do you obtain special consideration on "public utility emergency" calls, as distinguished from emergency calls placed by the public?

9. Have you worked out your Telephone Company contacts so that your operating organization can contact the proper authorities in the telephone organization any hour of the day and quickly, with a minimum of

explanations, obtain immediate repairs on any of your leased lines which have failed, or obtain substitute circuits possibly over other routes?

Power Supply

The method of handling load when a calamity can be forecast and is approaching the system, and it looks as though generating stations will be lost, is important. Shall customers be requested to drop their load before the stations need to shut down so that the industries can plan for their outage better and protect any products being manufactured, or shall the load be carried as long as possible and only dropped, possibly without warning, as the stations go down? Last Spring one company followed the first policy during the flood and had an embarrassing situation when one 180,000 kw station rode out the flood contrary to predictions. Nevertheless, the plan of reducing customers' load early in the emergency with the customers taking only enough load to meet emergency requirements seems to be the best plan. The dropping of lines or stations to get this load off should not be done except as a last resort. Outages of lines remove the availability of power for emergency needs. In extreme cases, though, circuits will have to be dropped, or stripped of non-essential customers to get power to emergency industries. Such action results in many complications.

Power companies recognize that hospitals, fire alarm systems, water pumping stations, railroad signal systems, airplane beacons, wholesale food supply houses and different essential industries are entitled to preferred service during emergencies. Likewise, the telephone exchanges should have preferred service. This last point needs emphasis. We insist that we obtain preferred service from the telephone companies in emergencies, using the argument that if we do not obtain adequate telephone service we may not be able to supply their power needs, in addition to the fact that we also are a public necessity. The Telephone Company is dependent on our power and we only hurt ourselves if we fail to keep power available to them.

When an emergency requires power outages of length or curtailment for several days, the power sales organization can contact customers best to keep them informed of conditions, and, of greater importance, can assign someone to work with the System Operating Department in the allocation of load. The Load Dispatchers can decide how much power is available, and what load the different circuits and stations can handle, but the power sales department can best decide what customers or services should get this power, or how its use should be staggered when there is a shortage. One can favor customers who can shut down over the evening peaks.

It is essential the Commercial Department employes work with our customers and the Operating Department to hold the load down, rather than hound the Operating Department for power that is not available. This plan requires a complete reversal of viewpoint for the average commercial man.

The System operating organization will have to contact some important customers during a power shortage. There are some customers these men usually do contact normally and these customers will look to this organization for the latest information. Then other customers will call every person they know in authority in attempts to obtain special consideration. One representative may contact the load dispatchers and others in the same company may contact separately our officers and our commercial departments. If we do not centralize these calls, both from the customer and in our own organization, confusion will result. It is essential that the contact man in a large industry during a power shortage be someone who can talk our own language, that he will know the load picked up or dropped for each unit started or stopped, the plant or parts of any plant they want to favor and the load required, the possibility of shutting down over the evening peak, the possibility of operating a shift after midnight, the best time certain interruptions can be taken, etc.

When one power company curtails power available to its customers to supply another utility during a calamity, the operating heads of the two companies must be in agreement on policy in supplying emergency power. Important industries, even if their product is not classed as essential, will not be favorable to restriction if they observe movies operating, if they see advertising signs burning brightly, or if they see street cars operating near normal. Then, we must be careful that we do not force one industry to shut down and permit a competitor in a nearby town to operate.

Do not allow the publicity department to advertise that power conditions are nearly normal if power is still curtailed to important industries, or if any neighboring utility is still curtailing its customers to supply you.

Interconnections

Our interconnections are our most important safeguards during disasters which affect our generating stations. Few appreciate the capabilities of these interconnections until they are put to maximum use during some calamity. Although this is an important subject, it is a subject about which there is little to discuss. The number, capacity, layout and use of these interconnections are dictated by local conditions.

Operating men prefer to have interconnections from all nearby neighboring companies as safeguards to service. We want the capacity of these tie lines to be as large as economic planning will justify. This size should not be governed entirely by the normal exchange of power, but consideration should be given to what the tie line can be required to carry when major troubles occur.

It is advisable to study existing interconnections to obtain the greatest possible use from them during these major calamities. The exchange limitations may not be on the interconnections, but in the stations or lines serving them. For example, during the last Spring's flood the current transformer ratios at Charleroi Substation were one of the limiting factors in the amount of power that could be brought into Pennsylvania from the West.

Every effort should be utilized to keep important tie lines in service. When normal relay protection is not available, back up protection can often be had by extending the line to another station. When it is impossible to maintain the normal protection or set-up on either end of any interconnecting transmission line each company should recognize that the other will take all necessary precautions in assuring adequate protection on these interconnections. No line should be opened simply because the conditions at the other end are not known.

When a calamity occurs, and as soon as a picture of conditions can be obtained, establish contact with your operating friends in each of the utilities with whom you interconnect. Possibly the trouble has extended to his system; he may not be able to call you, and he may need help. Because of our being allowed preferred use in placing telephone calls out of a trouble area, we usually can place calls from these trouble areas to points beyond the trouble when they cannot call us. Even if no interchange

power is taken the picture of outside conditions obtained from these conversations are valuable. Then our neighbors may have ways of helping we had not thought about. Often voltage help is wanted as much as power and help in voltage may not be offered unless requested.

It may be well to remember that emergency power over some interconnections often carries a relatively high cost. Even though we need this power and are glad to take it, any understanding about these costs, or the regulation of this power especially when off peak, that can be reached by the operating organizations of the interconnected companies in advance may result in considerable savings later.

System Layout

The planning of a transmission system to meet system operating requirements is of special importance to those who live with the system from day to day. Such plans are dependent so much on local conditions, though, only general suggestions can be offered. Nevertheless, some suggestions can be offered from different emergencies experienced.

When more than three important lines, which cannot be left de-energized without jeopardizing service, connect to a high voltage bus, it should be possible to so sectionalize this bus that no more than three lines will be kept energized on one section should the controls for their breakers be lost. Such sectionalizing need not be automatic. It could be obtained by removing jumpers or opening disconnects.

It is desirable that when two or more lines come into a station from the same load area that each of these lines terminates on a different bus section. This arrangement complicates the problem of relaying these lines and may prevent balanced protection on such lines if a bus sectionalizing breaker between the lines is opened, but other good methods of relay protection are available.

When a small station cuts two or more transmission lines, it is suggested that one or more of these lines should by-pass the station with no more than a tap into it as a protection against local troubles splitting apart the system.

When a large substation is lost, such a large area is affected that it seems better engineering practice to serve a community from several small stations rather than one large station and then have the distribution so interconnected that it can be thrown from one station to the other.

The occasional calamities which shut down power stations and isolate important load areas from their normal sources of supply, bring a serious voltage problem in these areas, especially if ample power can be obtained only with an unplanned large voltage drop. Equipping transformers with external tap changers is a partial solution. Unfortunately, this is not the complete answer to this problem, for economics requires that one standardize in the selection of transformer taps in a range of possibly 10 per cent or 12 per cent maximum change. When these transformers are used in a part of the system where a lower high side voltage necessitates reducing the ratio between the high and low voltage we limit the adjustment that can be made during any emergency.

In conclusion, the following suggestions are offered to company officers to assist their operating organizations during such calamities.

1. Maintain yourselves available for advice and decisions on major policies, but do not try to direct the actual operations of the system.

2. Assign those directing rehabilitation and the operation of the system full authority to make decisions and issue orders pertaining to all operating matters or the emergency as long as they do not conflict with the policies you have outlined.

3. Assure that communication will be maintained between the trouble centers and the system operating headquarters when normal means of communication fail, so that all changes in load, stations, capacity and the power system will be known quickly.

4. Keep other departments from bothering the system operating department and those directing emergency organizations with unimportant matters and questions.

5. Check that the Stores and Purchasing Departments are organized to handle the requests from the trouble areas for material.

6. Make certain that responsible members of the Commercial Department are working with the system operators to take and keep off load where necessary and to allocate available load to where it can be best used and that these men are handling all customer contacts to keep the load dispatchers free to handle their own work.

7. Be certain that all emergency organizations have available good food, pure water, warm and dry clothing, ample transportation facilities, comfortable places to sleep and toilet facilities. As soon as possible all food should be selected to give a balanced diet.

Discussion with other large companies which have experienced this problem brought out that an experienced caterer can often handle the food problem for large isolated groups better than a hotel or restaurant who have plenty of worries of their own. Any large wholesale food supply house can locate a competent caterer.

8. Obtain as soon as possible passes to give the organization unrestricted movement through any devastated area which is under police restriction or martial law.

9. Organize capable personnel to handle the publicity covering the disaster and to obtain and collect photographs and news covering all phases of the calamity.

Editors View Socialistic Issue

THE *Industrial News Review* recently asked country newspaper editors for their opinion on various phases of the "Power Question." With around 1200 replies now tabulated, some extremely interesting facts are being produced.

Only 42 of the editors said that the utility industry is not giving good service—while 1111 feel that service is good. Only 295 editors favor municipal ownership of power plants, while 863 are against it. While 250 editors believe Federal electric developments are justified as a national necessity, over 900 believe they are unjustified. Contrasted with 891 editors opposed to the wholesale death sentence for holding companies, only 210 approve it.

Most important of all, perhaps, only 157 editors believe that government or municipal ownership of the electric industry would give more progressive, efficient and cheaper service, taxes and public subsidies considered, as against 947 who feel otherwise.

It is very probable that these percentages showing overwhelming opposition to any socialist trend that would put the government into business to the injury or destruction of private enterprise, represent the general feeling of informed citizens. It was not accidental that in the last election voters turned thumbs down on proposed local measures to put various states into business. The American people, for example, realize that the private electric industry, under public regulation, has been one of the most beneficial and progressive influences in our social and industrial life—and they likewise sense the manifold dangers that inevitably follow when bureaucrats are given control or management of an essential business.

These answers of editors provide an illuminating and valuable commentary on one of the most discussed questions of the time. They are encouraging to those who feel that private enterprise is better than socialism, and that the role of government in business is properly that of umpire, not a favored participant.—*Industrial News Review.*

Regulation of Electrical Utilities in Foreign Countries

A Review of the World Power Conference Papers on This Subject

By Alexander Maxwell

Director of Engineering, Edison Electric Institute

AMONG the eighteen topics scheduled in the program of the Third World Power Conference, three dealt directly with public utility organizations as such. These were: "Organization of Private Electric and Gas Utilities," "Public Regulation of Privately Owned Electric and Gas Utilities" and "Organization, Financing and Operation of Publicly Owned Electric and Gas Utilities." Inasmuch as all three of these topics were actually directed toward the control and regulatory problems that have recently had much attention from official circles in the United States, it is appropriate to review this group of topics and papers from the point of view of regulation.

This calls for particular attention to the group of papers addressed specifically to the subject of regulation, but with occasional reference to the other two topics so far as they bear upon regulation. It is not possible within the limits of a brief article to deal extensively with the primary purposes of these papers other than regulation, but some of them are well worth study on their own account; for example, the extensive expositions of municipal plant practice contained in the papers of Mr. H. C. Lamb for Great Britain, Dr. Strickler for Switzerland and Mr. E. F. Scattergood for the United States.

With regard to the problem of regulation, as developed by the papers devoted to this topic, the following limitations are suggested by study of the texts. In the first place, the only foreign experiences which can be said to offer sufficient comparisons with American experience are those of the highly industrialized countries of Western Europe. It is quite plain that the policies of countries that are but meagerly developed industrially or electrically have little significance. Thus in several South American countries and in the Orient there appears to be almost complete dependance upon foreign capital and foreign enterprise. Likewise in the electrically more backward countries of Eastern Europe it may be observed that the service of electricity supply is almost in the pioneer stage and there is no useful experience to support opinion and policy.

In the reports prepared by the American "General Reporters" summarizing the various groups of papers, this aspect of the matter has apparently escaped attention. There are several instances where one practice or another is supported by reference to the opinions, or the experiences of the South American countries, or China, or Manchukuo, along with the policies of the great industrial countries of Western Europe, without discrimination,

Another precaution that needs to be taken is regard for the very recent appearance of some of the regulatory legislation described in the various papers. Much of this legislation, arising out of the economic crisis or out of recent political events, was actually but a few months old when the papers from the countries concerned were written. Thus, to list a few of the more prominent recent legislative acts, there are:

Germany—The Energie Wirtschaft Gesetz, a thoroughgoing act of nation-wide application, fully in harmony with the principles of the existing regime in Germany, enacted December 13, 1935.

France—The Decret-Lois (ministerial decrees authorized by law) of July and October, 1935, promulgated by the present government as part of a comprehensive series actuated by the fiscal crisis in that country.

Great Britain—The two most significant recent developments are the creation of the Central Electricity Board and its "Grid," which is not yet functioning in all parts of the country, and the report on the distribution of electricity from the McGowan Committee which has actually not been translated into legislation and which, in fact, appeared too late in 1936 for extensive consideration in any of the British papers.

Austria—A new Federal Act in 1934.

Denmark—Electric power legislation in 1935.

Bulgaria—Electric power legislation in 1934.

Of course the eminent authors of the papers from all of the countries concerned give full consideration to the effects of prior legislation and describe merely the intent and, according to their points of view, what may be expected from the latest legislation. So much cannot be said, however, for the American summaries and analyses that have appeared so far, where at the least it may be said that there is not adequate recognition of the fact that the electrical development in the progressive countries has attained its growth under decidedly liberal conditions.

The prospectus of the American Committee was designed, not unnaturally, to bring out evidence and opinion upon points that have been much under discussion in the United States. Particularly, the questions of Federal versus State regulation, rate control, competition whether territorially or as between private and municipal undertakings, and the "yardstick" idea. As noted in an earlier review of another World Power Conference topic,* this rather insistent pre-determination of what the foreign authors should talk about did not have a wholly beneficial effect upon the foreign papers. In most cases the foreign contributors politely and laboriously endeavored to comply, which led to more than a little aimless writing upon topics that apparently had little or no significance in their countries. A more serious effect, however, seems to be that in certain cases some of the contributors refer only briefly to matters which were apparently of considerable importance in their countries.

The American Contribution

The papers contributed to the subject of regulation by the United States were those of Mr. John E. Zimmermann from the point of view of the utilities, and of Messrs. W. E. Mosher and J. C. Bonbright jointly, from the point of view of critics of existing methods of regulation. Although widely divergent in import, both papers describe in detail the mechanism of regulation in the United States and so, no doubt, are

*E.E.I. BULLETIN, Page 445, Nov., 1936.

adequately informative to foreign readers.

On the collateral subjects of "Organization of private utilities" and "Organization, etc., of publicly owned utilities" papers were presented from governmental sources by Messrs. R. E. Healy and E. F. Scattergood respectively. Judge Healy's paper is essentially a tract upon holding companies and is not very useful to those who might require the concrete information suggested by the title; Mr. Scattergood's paper, on the other hand, is highly informative. A paper on the first subject from the point of view of the industry was contributed by Mr. J. F. Fogarty. It is not proposed to discuss these papers in further detail as the subject matter is readily available in numerous American publications, and is well known to the industry.

The remainder of this article will be devoted to a notice and résumé of the more important or interesting points contained in the foreign papers on regulation from the highly industrialized countries of Western Europe. Limitations of space make it impossible to present a systematic review of the papers from all contributing countries and moreover, as already shown, there is no real comparison with American conditions except in a few countries. Many of the papers from the smaller countries are ably prepared and have good specific interest; it is from the point of view of their value for comparative purposes that they have been omitted here.

THE EUROPEAN CONTRIBUTION

Great Britain

The population of Great Britain is 44,790,000 and its area is 88,745 square miles. The total output of electricity by authorized undertakers in 1934 (electric utilities, as we would say in the United States) is 12,781,600,000 kwhr of which 37 per cent is supplied by privately owned utilities and 63 per cent by municipal undertakings. The total number of undertakers is 631, of which 252 or 40 per cent are private and 379 or 60 per cent are municipal. Gas utilities distributing manufactured gas are well established nearly everywhere and offer stiff competition which is supplemented by the characteristic British resistance to change.

The British paper on Regulation of Electric Utilities was contributed by Mr. John C. Dalton, who is manager of the County of London Supply Co., Ltd. Early legislation, from the first Electric Lighting Act in 1882 down to and through the period of the World War, was not characterized by any rounded concept of regulation although there were scattering regulatory requirements which were administered by the Board of Trade. Nevertheless the general motive in the early legislation, namely, that the local authorities were the natural sponsors for electric supply undertakings and the private corporation the exceptional case, leading in the latter to short tenures, originally fifteen or twenty-one years, but since settled at forty-two years subject to renewals, had a profound effect upon later development. In general this effect has been an unfortunate one in the retardation of development of electricity supply, according to the opinions of nearly all critics, including those who lean to the public ownership side in principle.

In this period statutory powers to generate, distribute and sell electricity were granted equally to private companies and municipalities but almost invariably upon the basis of the local government area. In Great Britain the units of local government are small and this circumstance, together with the then state of the art, resulted in a very large number of independent, self-contained electricity supply enterprises, roughly two-fifths privately owned and three-fifths municipal. At a later date, but prior to the post-war legislation, a number of privately owned "power companies" were organized under perpetual franchises. These companies were empowered to supply extensive areas, had large and efficient generating stations and employed high-tension transmission. The principal business of these companies consists of industrial and bulk power supply but they also do an extensive business in general distribution mainly, however, in the less densely populated districts not already pre-empted by local "lighting" undertakers.

The present regulatory system in Great Britain dates from the important legislation enacted after the World War. The Electricity (Supply) Act of 1919 set up a Board of Electricity Commissioners, a regulatory body, and transferred the administration of regulation from the Board of Trade to the Minister of Transport who also has certain regulatory powers beyond those vested in the Electricity Commissioners. The Electricity (Supply) Act of 1926 set up the Central Electricity Board which dominates the power generation and bulk supply field and operates the "Grid" of high tension transmission lines.

In view of persistent mis-statements in America concerning the role played by the Central Electricity Board, its functions will be re-stated at the risk of repetition. The Central Electricity Board is a utility and is subject to regulation by the Electricity Commissioners like any other utility. The question whether or not it is a public or a private utility is subject to definition. Mr. H. C. Lamb in his paper on British publicly owned utilities counts the Central Electricity Board as one of them. On the other hand it is not financed by public monies of any kind, but solely by the public sale of its securities. In theory the profits of trading, if any after discharging the operating expenses of the Board, would be applied to reducing the costs of bulk energy; the question is somewhat academic at the moment, as the CEB is systematically capitalizing interest and is therefore, as an American commentator has said, engaged in a race with compound interest. In spite of all this Messrs. Fournier and Walsh, the General Reporters for the subject "Regulation," describe the Central Electricity Board as "another governmental authority."

The Electricity Commissioners have extensive regulatory powers. Their consent is necessary for the establishment or extension of generating and transmission plant and they grant the necessary orders for supply in particular areas, and for other definite purposes, for example to fix the scale of depreciation in respect of the purchase of an undertaking. The consent of the Commissioners is also required for the borrowing of money by municipalities, joint authorities (associations of public bodies covering considerable areas; there are three of these) and the Central Electricity Board.

The Minister of Transport exercises direct powers with respect to the revision of maximum rates, which are fixed in the original orders granted by Parliament to undertakers, to the approval of overhead lines, a sensitive subject in England, and to the obtaining of rights-of-way, a more difficult thing in England than in the United States. All of these actions, however, are with the advice of the Electricity Commissioners.

The establishment of a maximum rate is obviously a much more simple process than the examination and approval of entire schedules. In practice it appears that this maximum is an outside precau-

tion at best as the commercial tariffs are invariably well below the maximum. In 1925, by an Act of Parliament, the companies operating in London were placed upon a sliding scale of tariffs and dividends, similar in principle to the well-known "Washington Plan" in the United States.

The Electricity (Supply) Act of 1919 also made possible, but not compulsory, the establishment of "Joint Electricity Authorities." These are described by Mr. W. B. Woodhouse, author of the British paper on private utilities, as follows:

"They were to be public bodies, consisting of representatives of local authorities and other interests who would, in suitable regions, purchase and unify the existing municipal and company electricity undertakings. Their capital was to be raised as loans on the security of the unified undertaking, and they were to work the undertaking so as to supply at the lowest prices consistent with the payment of working expenses and the capital charges for interest and loan repayment by means of a sinking fund.

"Both municipalities and companies were, for various reasons, indisposed to hand over their businesses to such a body and no general solution of the difficulties was secured. The objections to 'joint electricity authorities" were to some extent due to a feeling that the constitution of the governing body would not insure efficiency and progress in that the members would be elected to represent sectional interests and not solely to secure the efficient management of the business."

Only three of these bodies now exist, one in the Metropolitan District and two in the Midlands. Concerning them, Mr. Dalton says:

"Practically nothing came of these ambitious proposals and there is really only one such joint electricity authority in the midland counties of the country to which all the generating stations have been transferred and which really functions as was provided for under the 1919 act. The idea, of course, of these representative bodies—composed probably of representatives of 20 or so municipalities, a few company members, and others from workers in the industry—to run a business, had to fail. *It is the experience in Great Britain that no business can be run properly where the political element may become predominant over technical and business considerations,*" (Italics ours.)

France

The population of France is 41,928,000 and its area is 212,659 square miles. The total production of electricity in 1934 was 15,172,400,000 kwhr of which 53 per cent was generated by steam stations and 47 per cent by hydraulic plants. This proportion has been steadily shifting toward increased hydraulic production since 1931; for the first three months of 1936 the proportions were: steam, 44 per cent; hydraulic, 56 per cent. At the beginning of 1936 the distribution of electricity undertakings was

	Communal	Syndicates of Communes	Departmental	Nat'l	Transmiss.	Other
Concessions to private undertakers	13,814	1,527	2	127	121	510
Publicly owned undertakings	227	36	3	...	...	...

The total of 16,101 private undertakings are owned by 1719 companies and comprise about 98.5 per cent of all undertakings.

The French contribution to the subject "Regulation" was prepared by M. E. Genisseau, Ingenieur en Chef des Ponts et Chaussees. Useful contributions to the subject also occur in the papers of M. E. Roux on "Private Utilities" and M. J. Aubert on "Publicly Owned Electric Utilities." In France the conduct of general electricity supply is almost entirely in the hands of private utilities operating under concessions from the commune, comparable with our municipal franchises. Power generation on a wholesale scale, particularly hydraulic generation, and the bulk transmission incident thereto are conducted by companies specializing in this field. These concerns are subject to different regulation and in some cases have received government subsidies.

The period 1884-1906 was practically devoid of any form of regulation, the only formality necessary was the procurement of a form of highway permit from the commune, department or prefecture according to the public ways that were to be occupied. In 1906 a law was enacted under which utilities acquired both rights and obligations, and further legislation in 1925 confirmed the practice of granting concessions which contain regulatory provisions arising out of the statutory provisions governing these concessions or out of contractual relations with the local authorities granting the concessions. The ground covered by regulatory provisions includes tariffs, duration of franchise, obligation to serve, and other features familiar in our own utility commission regulation, and various technical requirements. The regulations derived from statutory sources are administered by a national agency, the Ministry of Public Works, in part by direct intervention, particularly in technical matters, and in part as an adviser and consultant to the local authorities.

Under parliamentary authority, ministerial decrees of July 16 and October 30, 1935, effected radical changes in the situation of distributing utilities as part of a general program for dealing with the economic crisis. These decree-laws also affected the production of electricity as will appear later. These decrees provide limitations upon tariffs in excess of the limitations already imposed by local franchises, and for the relief of those enterprises unable to survive under the new tariffs to the extent of facilitating purchase by financially stronger neighbors.

In the field of bulk generation and transmission, which is quite sharply differentiated from local distribution in all of the French contributions, the conditions are somewhat different. Hydraulic power developments were subject to ancient laws until 1919, when the law of October 16th of that year regularized both the rights and duties of such undertakings. The principal feature was the requirement for state authorization for a project, limitation to a 75-year term renewable indefinitely for 30-year periods, eminent domain, a moderate degree of rate control and conformity with technical requirements. This same law of 1919, however, left steam generating stations free from regulation.

The decree-laws of 1935 established regulations affecting the further construction of both steam and hydraulic stations, and these decrees have actually been employed to enhance hydraulic output and diminish steam output, in the interest of fuel economy and diminution of import fuel.

Financial participation by governmental bodies in the form of subsidies or other investments in electricity supply works has been relatively small and practically confined to the National Government. These governmental expenditures have been limited to some assistance to rural electrification, and more substantial, although still proportionately small, contributions to hydraulic power developments and bulk transmission, as well as some direct assistance toward the electric supply of the devastated regions following the World War. The form of this financial par-

ticipation has been in subsidies in the lesser cases, but the more important expenditures have been for the encouragement of hydraulic and bulk transmission projects and these have been in the form of loans or purchases of stock. In the latter case the government participates in the direction of the enterprise. According to M. Aubert, the governmental participation has been as follows:

"In the case of power-production companies, which have invested about 8000 millions of francs in the construction of hydro-electric stations, State subsidies have amounted to only 22 million in capital bearing interest in perpetuity, 55 million in redeemable capital, and 9 million per annum subject to participation in profits."

The most important example in France, of governmental participation in a large-scale attempt at collaboration between the State, local governmental authorities and privately owned electric utilities, is that of the Compagnie Nationale du Rhône. This enterprise is described in the paper of M. Aubert, the Director General of the Company. This paper constitutes the French contribution to the topic "Publicly Owned Utilities."

This enterprise may have a special interest to Americans because of certain striking parallels with the TVA. The proposal is for the development of a river valley, that of the Rhône, for a distance of 450 km (roughly 275 miles) in the interests of navigation, irrigation and power development. Further parallels appear, in the discussion of these features. Of navigation, M. Aubert says:

"It is a navigable stream which, until the coming of steam railways, was extremely important as a waterway. Its importance from this angle has since diminished, although many development schemes—some of which date from a century ago—have been since formulated."

And of irrigation, on page 8:

"The Rhône is equally important from a third point of view, that of irrigation. Irrigation makes possible a rich agricultural output in areas where absence of rain does not permit farming without irrigation."

But on page 11:

"No irrigation work is being undertaken since agricultural production in the south-eastern region of France is considered sufficient."

The enterprise is estimated to require 15 billions of francs for the "integrated development of the river as a whole." Toward this the company has been organized under a financial plan that contemplates the raising of capital in the ratio one-tenth capital stock and nine-tenths of bonds. To this end the nominal capital has been fixed at 240 million francs to establish a total of 2.4 billions francs or 16 per cent of the estimated requirements. Of this 240 millions of capital stock, 60 millions have actually been subscribed.

A special law was enacted in 1921 to charter the enterprise and the company was definitely constituted on May 27, 1933. Its board of directors consists of six representatives each from four groups, the Department of the Seine, the PLM Railway which operates in the Rhône valley, the local governmental, commercial and agricultural interests of the Rhône region, and a group of 66 private electric companies. In addition there are 16 directors representative of the State, making 40 in all. Not unnaturally, most of the directors' work is done by a committee of twelve, consisting of 8 shareholders' directors and 4 State directors.

Work actually under way appears to consist of a "large industrial port in the vicinity of Lyon."

Germany

The population of Germany is 65,969,052 and its area is 186,627 square miles. The total production of electricity by public utilities for 1935 (estimated) was 19,100,000,000 kwhr, of which 49 per cent was produced by publicly owned utilities, 11 per cent by private utilities and 40 per cent by utilities of mixed ownership. In addition industrial plants (eigenanlagen) produce a relatively large amount of energy, about 75 per cent as much as that produced by utilities, an amount estimated for 1935 to be 14,500,000,000 kwhr, giving a total production of energy for that year of 33,600,000,000 kwhr (estimated). The outstanding characteristic of German development is the assiduous development of brown-coal fuel plants, along with such hydraulic resources as the country possesses. In 1934 the production of energy according to sources was: coal, 36 per cent; brown-coal and peat, 42 per cent; hydraulic power, 15 per cent and gas, 7 per cent.

The German paper on "Regulation of Privately Owned Utilities" was contributed by Messrs. C. Krecke and G. Seebauer who discuss the German system of regulation which is applied uniformly to all utilities regardless of ownership. This paper, and some of the other German contributions, are strongly biased toward an exposition of the social and political philosophy of the current National-Socialist regime which, among other things, appears to include a hearty disapprobation for anything that occurred prior to 1933, especially the "period of political decline" —namely, the years of the Republic, 1918-1933.

Under the circumstances, these papers are not very reliable witnesses for the regulations that were current during the period of expansion of electric supply. Moreover the question is further complicated by the fact that there were substantial differences among the constituent states of the Republic and the old Empire. However there is sufficient evidence to indicate that regulatory provisions were designed to promote and encourage development and were invariably in conformity with the technical and commerical conditions. The actual exercise of regulatory authority was principally through control of the use of public ways and there was little interference with the commercial development of rates. Under these circumstances it may fairly be said that the industry was self-regulated, developing according to technical and economic requirements and the dictates of business judgment.

On this score the preamble to the Energy Economy Act of December 13, 1935, which itself sets up a different state of affairs, says:

"The technical efficiency of German energy generation and distribution has always been recognized as being of a high standard. . . . From a standpoint of technical development it has proven to be the best policy so far to let the utilities follow their own course, unrestricted by legal control."

Since all German discussions, and the recent legislation, deal with all utilities substantially without regard to ownerships and since the enterprises that are, in reality, publicly owned, have much the same organization and business viewpoint as the privately owned enterprises, a brief survey of ownership conditions may be useful. Except for the earliest pioneer period, public ownership has always been a substantial and increasing element in the business; at present only about 10 per cent of the industry is under purely private ownership. On the other hand the types of pure public ownership, as by municipal or other local government electricity departments are also rather rare. The outstanding types are the "mixed-company" and the corporations formed by governmental elements. Of the mixed company Pro-

(*Continued on page* 516)

McGraw Prize Paper

Operation of Oil Insulated Transformers On a Temperature Basis

By Elwood A. Church

FORMERLY loads above the name plate rating on transformers were not recognized as safe under any circumstances. Transformers were rated in accordance with A.I.E.E. Standard No. 13-200, which allow 55° C. tested winding rise by resistance measurement as long as the ambient does not exceed 40° C. If the conventional hot-spot rise above average of 10° C. is assumed the maximum insulation hot-spot temperature would be 105° C.

Transformers loaded in accordance with the above rule would not attain their temperature limit unless the following four conditions occur simultaneously:

1. 40° C. ambient.
2. Rated load continuously
3. Tested rise of 55° C. by resistance.
4. Conventional rise of 10° C. for hot spot above average.

It would be safe to assume that never would all of the above conditions occur simultaneously except under very special conditions. Consequently there arose a demand that transformers should be loaded on a temperature basis, allowing loads in excess of the name plate rating as long as the winding temperature did not exceed a certain specified value. Manufacturers met this demand by providing temperature indicators in various forms on transformers.

It was at once recognized that if transformers were operated on a temperature basis, higher average temperatures would be reached and maintained for long periods and there was some doubt that 105° C. hot-spot temperature was a safe limit. It was decided, that at least until operating experience indicated that 105° C. could be maintained for long periods without injury to the insulation, that the limit should be decreased to 95° for operation on a temperature basis. Subsequent tests and operating experience have demonstrated that this was a wise procedure, indications being that if transformers as at present manufactured were operated at a temperature of 105° C. continuously, their life would only be a few years.[7]

In 1930, the A.I.E.E. Standard No. 100 was adopted recognizing loads above the name plate rating. In this standard, transformers equipped with winding temperature indicators were allowed to be loaded above the name plate rating provided the winding temperature by resistance method did not exceed 85° C. or, if the indicator was scaled in terms of hot-spot temperature, 95° C. When not equipped with winding temperature indicators, they were allowed 1 per cent increase in load above the name plate rating for every degree the ambient was below 30° C. for oil-insulated self-cooled transformers, and 25° C. for water-cooled transfermers, down to a limit of 0° C. Self-cooled transformers could thus be loaded to a maximum continuous load of 130 per cent, and water-cooled transformers 125 per cent of name plate rating in 0 deg. ambient.

This was a step in the right direction, but still left much to be desired in rating transformers under actual operating conditions where a continuous load is seldom if ever experienced.

All oil-insulated transformers have a very large capacity for heat storage in the material composing tanks and core, and especially in the oil. This large heat storage capacity smooths out the temperature cycle as the load cycle is applied, the maximum oil and winding temperatures thereby not approaching the values which would be reached as a result of a continuous load by a large margin. As a result loads considerably higher than allowed by the above so-called one per cent rule may be applied to transformers operating under the usual daily load cycles.

It is the purpose of this paper to develop methods of rating transformers for short time overloads and for normal operating conditions. For short time overloads the temperature rise curves for various suddenly applied steady loads will be calculated, and the results shown in charts. Ratings for various times of application of the loads can be determined from these charts. For normal operating conditions the temperature cycle has been computed by splitting the load cycle into harmonics, and adding the harmonic temperature rises obtained therefrom. The data necessary for calculating temperatures and ratings is readily obtained from the manufacturers

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Mr. Church's work with the Boston company is currently devoted to station and transmission engineering problems.

[7] For all numbered references see Bibliography appended.

of the transformers and consists of the oil and winding temperature rises at rated load, as determined from their test data, the iron and copper losses at rated load, and the weights of the various component parts of the transformer, namely: windings, core, oil, and case. For water-cooled transformers the temperature difference between outgoing and incoming water is also necessary.

Temperature Rise for Suddenly Applied Load

The theory of transient temperature rise will be developed for oil-insulated self-cooled transformers and subsequently extended to include water-cooled transformers.

It would be a simple matter to compute temperature rise curves for transformers if the thermal circuit were a linear function. However, some of the heat is dissipated from the surface of the case by convection currents in the ambient air and some by radiation, and the ultimate temperature rise for any given steady heat flow is hence not a linear function, being expressed very closely for the range of temperatures met with in loading transformers by the equation:

$$T_1^n = K_1 Q_1 \qquad (1)$$

where T_1 = oil temperature rise
K_1 = thermal resistance from oil to air
Q_1 = sum of core and copper losses
n = an exponent usually greater than 1.0

Values of n for various cooling conditions are given in the following table:[2, 4]

1. Tank surface or oil rise over ambient	
a. With plain tank	1.19
b. With irregular surfaces	1.25
2. Winding rise either by resistance or hot spot over oil	
a. Having vertical coils	1.00
b. Having horizontal coils	1.25

The majority of the modern self-cooled transformers are constructed with vertical coils and the tanks have either corrugations or radiators to increase the heat dissipating surface. Hence the value of n is usually 1.25 for oil rise over ambient and 1.00 for winding rise over oil.

The charts shown in this paper will accordingly be drawn for these constants.

During the transient state of temperature rise the complete thermal circuit of the transformer must be used. The analogous electrical circuit is a resistance and capacitance in parallel in a constant current circuit, the current corresponding to the heat flow, the potential rise across the resistance and condenser corresponding to the temperature rise, and the capacitance corresponding to the thermal capacity of the transformer.

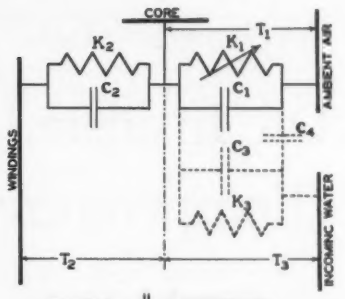

Fig. 1—Thermal Circuit of Oil-Insulated Transformers in terms of Electrical Analogies.

In handling the problem of transient temperature rise, the thermal circuit of the oil-insulated self-cooled transformer will be separated into two parts, ambient to oil, and oil to copper as shown in Fig. 1. This is necessary since the characteristics of the two parts are radically different.

It will be convenient for presentation of the problem to first consider that the thermal circuit is entirely linear, and then apply modifications to the results to take care of the variable thermal resistance element, oil to ambient air.

Assuming the thermal circuit to be linear, the simultaneous differential equations governing the heat flow are as follows:

$$T_1 = K_1 \left\{ Q_1 - \frac{dq_1}{dt} - \frac{dq_2}{dt} \right\} \qquad (2)$$

$$T_2 = K_2 \left\{ Q_2 - \frac{dq_2}{dt} \right\} \qquad (3)$$

$$\frac{1}{C_1} \left\{ \frac{dq_1}{dt} \right\} = \frac{dT}{dt} \qquad (4)$$

$$\frac{1}{C_2} \left\{ \frac{dq_2}{dt} \right\} = \frac{dT_2}{dt} \qquad (5)$$

where T_1 = temperature rise of oil above ambient
T_2 = temperature rise of windings above oil
K_1 = thermal resistance from ambient air to oil
K_2 = thermal resistance from oil to windings
Q_1 = steady state heat flow from oil to ambient air (copper loss and iron loss)
Q_2 = steady state heat flow from windings to oil (copper loss)
q_1 = instantaneous heat flow from oil to ambient air
q_2 = instantaneous heat flow from windings to oil
C_1 = equivalent thermal capacity of oil, core, and case
C_2 = thermal capacity of windings
t = time

The solution of these equations is found in appendix C, the results being given as follows:

$$T_1 = K_1 Q_1 \left\{ 1 - \epsilon^{-\frac{1}{K_1 C_1} t} \right\} + \frac{K_1 K_2 C_2 Q_2}{K_1 C_1 - K_2 C_2} \left\{ \epsilon^{-\frac{1}{K_2 C_2} t} - \epsilon^{-\frac{1}{K_1 C_1} t} \right\} \qquad (6)$$

$$T_2 = K_2 Q_2 \left\{ 1 - \epsilon^{-\frac{1}{K_2 C_2} t} \right\} \qquad (7)$$

For oil-insulated self-cooled transformers, K_2C_2 is only a small fraction of K_1C_1, the usual ratio being from 1/20 to 1/50 depending upon the design of the transformer.

Hence with negligible error equation 6 may be simplified as follows:

$$T_1 = K_1 Q_1 \left\{ 1 - \epsilon^{-\frac{1}{K_1 C_1} t} \right\} + K_2 Q_2 \left\{ \frac{C_2}{C_1} \right\} \left\{ \epsilon^{-\frac{1}{K_2 C_2} t} - \epsilon^{-\frac{1}{K_1 C_1} t} \right\} \qquad (8)$$

C_2 is usually small compared to C_1 so very little error will be made if the second term is eliminated altogether especially for large values of time. Thus:

$$T_1 = K_1 Q_1 \left\{ 1 - \epsilon^{-\frac{1}{K_1 C_1} t} \right\} \qquad (9)$$

$$T_2 = K_2 Q_2 \left\{ 1 - \epsilon^{-\frac{1}{K_2 C_2} t} \right\} \qquad (7)$$

The second term of equation 8 takes care of the attenuation of heat flow in passing through the winding insulation. If this attenuation is neglected, equation 9 may be derived directly assuming steady heat flow suddenly applied to the oil. Temperature rise curves computed from equations 7, 8, and 9 are shown in Fig. 2, along with a curve of equation 12, taking into account the non-linearity of the thermal circuit from ambient air to oil.

There is seen to be negligible difference between curves B and C and hence the temperature rises from ambient to oil and from oil to winding can be computed separately assuming suddenly applied steady heat flow for each. The fact that the thermal circuit from ambient to oil is non-linear will not affect the validity of this statement.

The differential equations determining the heat flow when the steady state is represented by equation 1 are as follows:

$$T_1^n = K_1 \left\{ Q_1 - \frac{dq_1}{dt} \right\} \qquad (10)$$

$$\frac{1}{C_1} \left\{ \frac{dq_1}{dt} \right\} = \frac{dT_1}{dt} \qquad (4)$$

The solution of these equations is given in appendix C and the result is shown as follows:

$$\frac{t}{K_1 C_1} = \frac{T_1}{K_1 Q_1} \left\{ 1 + \frac{1}{n+1} \left(\frac{T_1^n}{K_1 Q_1} \right) + \frac{1}{2n+1} \left(\frac{T_1^n}{K_1 Q_1} \right)^2 + \cdots \right\} - \frac{T_o}{K_1 Q_1} \left\{ 1 + \frac{1}{n+1} \left(\frac{T_o^n}{K_1 Q_1} \right) + \frac{1}{2n+1} \left(\frac{T_o^n}{K_1 Q_1} \right)^2 + \cdots \right\} \qquad (11)$$

where T_0 is the initial temperature rise corresponding to an initial steady heat flow of Q_0.

When $T_0 = 0$.

$$\frac{t}{K_1 C_1} = \frac{T_1}{K_1 Q_1} \left\{ 1 + \frac{1}{n+1} \left(\frac{T_1^n}{K_1 Q_1} \right) + \frac{1}{2n+1} \left(\frac{T_1^n}{K_1 Q_1} \right)^2 + \cdots \right\} \qquad (12)$$

For the purpose of calculating the short-time capacities of transformers with different initial loads it is convenient to construct a chart as shown in Fig. 3.[7] With this type of chart the infinite time scale is compressed to a finite quantity, and scaled such that the temperature rise curves are straight lines for convenience in construction and interpolation.

The time scale is direct reading when $KC\sigma = 1$. For the time scale, K is expressed in degrees per kilowatt of heat flow and is defined by the ratio:

$$\frac{\text{rated load temperature rise.}}{\text{rated load losses}}$$

The value of C, expressed in kilowatt-hours per degree of temperature rise, being the thermal capacity of the transformer, depends upon the weights of the various materials in the transformer and its method of computation is explained in appendix B.

The correction factor, σ, is added in order that temperature lines for all values of Q_1 may be straight lines. The value of σ is obviously given by the following equation:

$$\sigma = \frac{K'}{K} = \frac{\Delta T}{K \Delta Q} = \frac{T_1 - T_o}{T_1^n - T_o^n} \qquad (13)$$

Where K′ is the equivalent thermal resistance for any range of temperature ΔT. Values of σ for various values of T_1 and T_0 are given by the chart in Fig. 4.

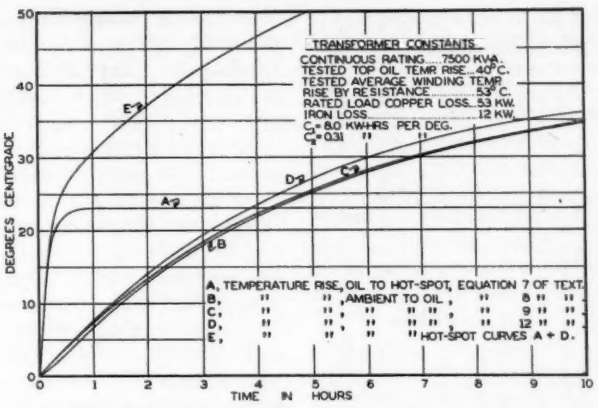
TRANSFORMER CONSTANTS
CONTINUOUS RATING....7500 KVA
TESTED TOP OIL TEMP. RISE...40° C.
TESTED AVERAGE WINDING TEMP. RISE BY RESISTANCE....53° C.
RATED LOAD COPPER LOSS...53 KW.
IRON LOSS....12 KW.
C = 8.0 KW-HRS PER DEG.
C₁ = 0.31 " "
A, TEMPERATURE RISE, OIL TO HOT-SPOT, EQUATION 7 OF TEXT.
B, " " AMBIENT TO OIL, " 8 " "
C, " " " " " " 9 " "
D, " " " " " " 12 " "
E, " " " " HOT-SPOT CURVES A + D.
DEGREES CENTIGRADE
TIME IN HOURS

Fig. 2—Calculated Temperature Rise Curves for typical Transformers. Continuous Steady Load applied following Zero Load.

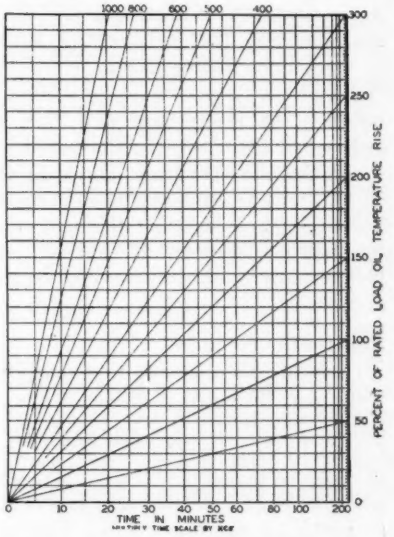

Fig. 3—Temperature Rise Chart for Self-Cooled Transformers.

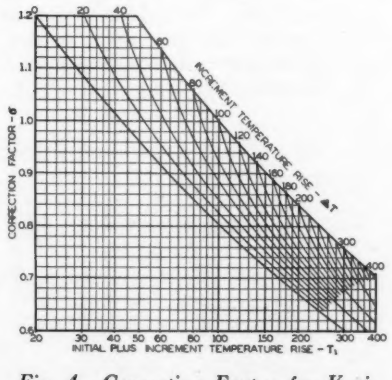

Fig. 4—Correction Factor for Variable Thermal Resistance.

$$\sigma = \frac{K'}{K} = \frac{T_1 - T_o}{T_1^n - T_o^n}, \text{ where } n = 1.25.$$

The chart in Fig. 5 has been drawn for convenience in obtaining the ultimate oil temperature rises for various steady loads and percentages of rated copper loss to total loss.

Copper temperature rises being a linear function of copper loss may be computed directly.

Short Time Overload Capacity of Transformers

It is not the purpose of this paper to determine the short time overload capacity of transformers on the basis of life of insulation at various temperatures. It will merely be assumed that, if the temperature of the windings does not exceed the limit given in A.I.E.E. Standard No. 100 for transformers equipped with winding temperature in-

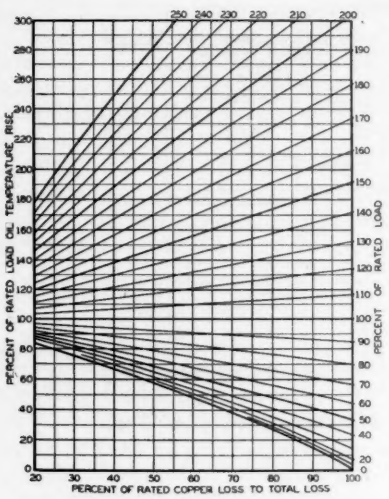

Fig. 5—Final Oil Temperature Rises for Steady Load.

dicators, the transformer will have a satisfactory length of life. Consequently a maximum hot-spot temperature rise of 95° C. will be assumed and short time loads computed such that this temperature will not be exceeded. The method will most easily be demonstrated by an example.

Example 1

Compute the maximum load which a 7500 kv-a oil insulated self-cooled transformer will carry for 2 hours for various ambient temperatures from 0 to 30° C. without exceeding 95 deg. hot-spot temperature after having been loaded at a continuous load of 75 per cent of rating for sufficient time previous to application of the overload to have reached steady temperature. The characteristics of the transformer are given as follows:

Temperature rise by resistance.....55° C.
Ratio oil temperature to total hot-spot rise 0.60
Copper loss....52 kw,..Iron loss....13 kw
Thermal capacity of windings..... .....0.30 kwhr per deg.
Thermal capacity of oil and iron..... .....8.0 kwhr per deg.

$$\text{Hence } K_1 = \frac{\text{Oil Rise}}{\text{Total Losses}} = 0.60 \text{ deg. per kw}$$

$$K_2 = \frac{\text{Hot-Spot Rise over Oil}}{\text{Copper Loss}} = 0.50 \text{ deg. per kw}$$

$$K_1C_1 = 0.60 \times 8.0 = 4.8$$

$$K_2C_2 = 0.50 \times 0.30 = 0.15$$

Substituting K_2C_2 in equation 7 it can be seen that the winding rise above oil reaches 99.8 per cent of its final value within an hour after the load is applied. The transient in the winding may, therefore, be neglected in figuring the total winding rise.

In general it may be stated that for practically all transformers the final winding rise above oil may be assumed to have been reached within an hour after a steady load is applied.

Assume four loads: 100 per cent, 120 per cent, 140 per cent, and 160 per cent, from which to plot a curve of hot-spot temperature rise above ambient versus load. Obtain steady state oil temperature rises from Fig. 5. Obtain values of σ from Fig. 4, and temperature rises at time t = 2 hours from Fig. 3 by laying a straight edge between the initial and final temperature rises and reading temperature at the ordinate $120/K_1C_1$.

Arranging the work in tabular form the following results are obtained:

Per Cent Load	Final Hot-Spot Rise above Oil		Final Oil Temp Rise = T_1		Per Cent ΔT	σ
	Per Cent	Deg.	Per Cent	Deg.		
100	100	26.0	100	39.0	29.0	0.825
120	144	37.5	127.5	49.8	56.5	0.805
140	196	51.0	158.0	61.6	87.0	0.780
160	256	66.6	191.5	74.8	120.5	0.747

Per Cent Load	$K_1C_1\sigma$	Ordinate in Fig. 3 for t = 2 hrs.	Oil Temp. at time t = 2 hrs.	Total Hot-Spot Rise over Ambient at t = 2 hrs.
100	3.96	30.3	32.4 deg.	58.4 deg.
120	3.86	31.1	37.0 "	74.5 "
140	3.74	32.0	42.5 "	93.5 "
160	3.59	33.4	49.0 "	115.6 "

From the plot of hot-spot temperature rise versus load obtained from the last two columns above, the loads which can be carried for two hours under the conditions set forth are given in the following table:

Ambient Temp.	0	10	20	30
Per Cent Load	142	132	121	109
Load in Kv-a	10650	9900	9080	8180

Cyclic Loading

The theories presented in previous paragraphs, while they give a complete exposition of the thermal characteristics of transformers and their ability to carry overloads during various assumed emergency conditions, do not permit calculation of the temperature rise of transformers when operating under normal conditions.

Two methods are feasible for calculating the temperature cycle and maximum temperatures under load cycles. The first method, one which has been extensively used,[7] is to divide the load cycle into a series of rectangular steps and compute the temperature cycle by a point-by-point method. This method has two disadvantages: (1) the thermal capacity of the average transformer is so large that at least two daily cycles must be computed before the maximum temperature is reached and, (2) the temperature cycle of each individual design of transformer must be computed separately on account of the non-linearity of the thermal circuit and the consequent impossibility of applying proportionate temperature rises for various values of losses.

The other method consists of splitting the load cycle into its component harmonics and computing the temperature rise for each harmonic.

The load cycles, in terms of per unit

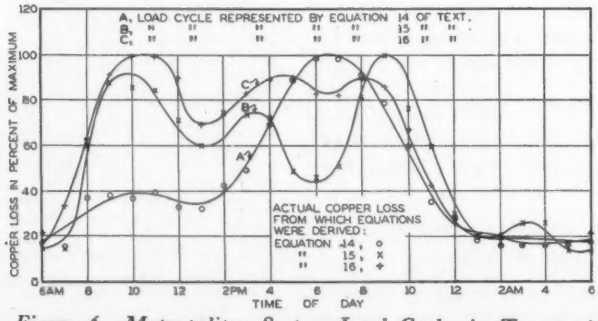
A, LOAD CYCLE REPRESENTED BY EQUATION 14 OF TEXT.
B, " " " " " 15 " "
C, " " " " " 16 " "
COPPER LOSS IN PERCENT OF MAXIMUM
ACTUAL COPPER LOSS FROM WHICH EQUATIONS WERE DERIVED:
EQUATION 14, o
" 15, x
" 16, +
TIME OF DAY

Figure 6—Metropolitan System Load Cycles in Terms of Per Cent of Peak Load Copper Loss.

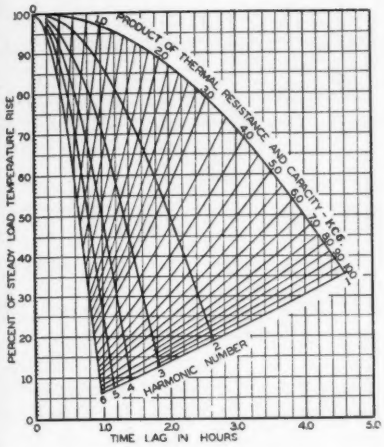
PERCENT OF STEADY LOAD TEMPERATURE RISE
TIME LAG IN HOURS
PRODUCT OF THERMAL RESISTANCE AND CAPACITY - KCθ
HARMONIC NUMBER

Fig. 7—Harmonic Temperature Rise Maxima with Time Lags.

$$T = \frac{KQ\sigma}{\sqrt{1 + (KC\omega N)^2}} \times 100\%,$$

$$t = \frac{24}{360N} \tan^{-1} (KC\omega N)$$

copper loss, most commonly met with in metropolitan systems may be grouped under the following three distinct types:

1. Residential load represented by the following equation in terms of its various harmonics on the basis of the fundamental period being 24 hours:

$$Q_2 = 0.440 + 0.330 (\sin\ \omega t - 5.90 \text{ hr.}) + 0.175 (\sin 2\,\omega t + 1.70 \text{ hr.}) + 0.073 (\sin 3\,\omega t - 2.40 \text{ hr.}) \quad (14)$$

2. Combination of industrial and residential with residential load predominant, represented by the following equation:

$$Q_2 = 0.560 + 0.252 (\sin\ \omega t - 3.36 \text{ hr.}) + 0.229 (\sin 2\,\omega t - 1.00 \text{ hr.}) + 0.045 (\sin 3\,\omega t + 3.37 \text{ hr.}) + 0.180 (\sin 4\,\omega t - 1.81 \text{ hr.}) \quad (15)$$

3. Combination of industrial and residential with industrial load predominant, represented by the following equation:

$$Q_2 = 0.610 + 0.380 (\sin\ \omega t - 3.00 \text{ hr.}) + 0.185 (\sin 2\,\omega t - 0.20 \text{ hr.}) + 0.085 (\sin 3\,\omega t - 2.20 \text{ hr.}) + 0.103 (\sin 4\,\omega t - 2.10 \text{ hr.}) + 0.028 (\sin 5\,\omega t + 1.27 \text{ hr.}) \quad (16)$$

The foregoing equations are shown in graphical form in Fig. 6 along with the original plotted points from which the equations were derived.

The non-linearity of the thermal circuit makes it impossible to add directly the various harmonic temperatures and obtain a resultant temperature cycle, but this may be overcome by the following device. Steady state temperature rises are computed corresponding to the constant component of heat flow, and steady loss equal to the maximum. The difference between these temperatures may be considered to be ΔT_1 for the purpose of entering the chart of Fig. 4 and obtaining a value for σ. This is equivalent to assuming that the thermal circuit is linear between the limits of the average and maximum losses.

This procedure is logical since the temperature variation at or near the maximum value is of primary interest. For instance, in the transformer described in example 1, and with the load cycle of Equation 14, at 140 per cent maximum load ΔT_1 will be 158 — 91.5 = 66.5 per cent from Fig. 5, the value 91.5 being the temperature rise corresponding to a load of $\sqrt{0.44}$ x 1.4 times rated load, 0.44 being the constant component of copper loss. Entering Fig. 4, σ is then equal to 0.760.

For convenience in computing the temperature cycle corresponding to any heat flow cycle, the chart shown in Fig. 7 has been constructed from the following data:

Assuming a linear circuit between the limits being considered, the equations for determining the harmonic temperature rises and time lags are as follows:

$$T = \frac{K'Q}{\sqrt{1 + (K'C\omega N)^2}} \text{ Sin } (N\omega t - \tan^{-1} K'C\omega N) \quad (17)$$

where K'Q is the steady state temperature rise corresponding to a steady heat flow of Q. If T is expressed in per cent of the steady state value the maximum is:

$$T_m = \frac{K'Q}{\sqrt{1 + (K'C\omega N)^2}} \times 100\% \quad (18)$$

The time lag in hours is expressed by the following equation if the fundamental period is taken as 24 hours, and $\tan^{-1} K'C$ is given in degrees:

$$t' = \frac{24}{360N} \tan^{-1} K'C\omega N \quad (19)$$

where N is the harmonic number.

In all of the above expressions, ω is the angular velocity, being 0.262 for the 24 hour fundamental period.

The method of using Fig. 7 to compute the temperature rise of a transformer for any load cycle is illustrated by the following example:

Example 2

Compute the equation of hot-spot temperature rise of the transformer in example 1 when loaded to a maximum load of 9800 kv-a with the load cycle of equation 14.

Temperature rise of winding above oil: Entering the chart of Fig. 7, the harmonic temperature rises and time lags for $K_2C_2 = 0.15$ for each harmonic are shown as follows:

1st Harmonic	
Temp. Rise	Time Lag
100%	0.15 hr.
2nd Harmonic	
Temp. Rise	Time Lag
99.5%	0.15 hr.
3rd Harmonic	
Temp. Rise	Time Lag
99%	0.15 hr.

Multiplying each harmonic of equation 14 by its corresponding factor in the above table and by 1.96 x 26 deg. and adding time lags, there is obtained the following equation for temperature rise from oil to hot spot.

$$T_2 = 22.4 + 16.8 (\sin\ \omega t — 6.05 \text{ hr.}) + 8.9 (\sin 2\,\omega t + 1.55 \text{ hr.}) + 3.7 (\sin 3\,\omega t — 2.55 \text{ hr.}) \text{ deg. Cent.} \quad (20)$$

Temperature rise of oil above ambient: Multiplying equation 14 by 1.96 and making an adjustment for the iron loss, there is obtained the following equation expressing Q_1 in terms of fractions of rated load total loss:

$$Q_1 = 0.890 + 0.518 (\sin\ \omega t - 5.90 \text{ hr.}) + 0.275 (\sin 2\,\omega t + 1.70 \text{ hr.}) + 0.115 (\sin 3\,\omega t - 2.40 \text{ hr.}) \quad (21)$$

Entering the chart of Fig. 7, the harmonic temperature rises and time lags for $K_1C_1\sigma$ (4.8 x 0.760 = 3.65) are shown as follows:

1st Harmonic	
Temp. Rise	Time Lag
72%	2.95 hr.
2nd Harmonic	
Temp. Rise	Time Lag
46.5%	2.08 hr.
3rd Harmonic	
Temp. Rise	Time Lag
32.5%	1.55 hr.

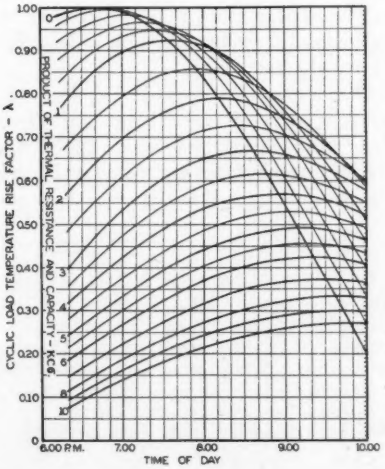

Fig 8—Temperature Rise Factors for the Load Cycle of Equation 14 of text.

Multiplying by the factors in the above table and by 39 deg. and correcting for the non-linearity of the thermal circuit, the following equation is obtained for the oil rise above ambient:

$$T_1 = (39 \times 0.915) + 39\sigma\,[\,0.518 \times 0.72\ (\sin\ \omega t - 8.85\ \text{hr.}) + 0.275 \times 0.465\ (\sin 2\,\omega t - 0.38\ \text{hr.}) + 0.115 \times 0.325\ (\sin 3\,\omega t - 3.95\ \text{hr.})\,] \quad (22)$$

where $Q_{av} = 0.980$, $T_{av} = 91.5\%$ from Fig. 5.
$Q_m = 115/65$, $T_m = 158\%$ " "
$\Delta T = 66.5\%$, $\sigma = 0.760$ " " 4. (23)

Hence $T_1 = 35.7 + 11.2\ (\sin\ \omega t - 8.85\ \text{hr.}) + 3.8\ (\sin 2\,\omega t - 0.38\ \text{hr.}) + 1.1\ (\sin 3\,\omega t - 3.95\ \text{hr.})$ deg. Cent. (24)

and $T_1 + T_2 = 58.1 + 26.2\ (\sin\ \omega t - 7.16\ \text{hr.}) + 11.4\ (\sin 2\,\omega t + 1.00\ \text{hr.}) + 4.3\ (\sin 3\,\omega t - 2.85\ \text{hr.})$ deg. Cent. (25)

The maximum value of equation 25 is 99.0 and hence the total hot-spot rise over ambient is 99.0° C.

If the temperature rises of a large number of transformers were to be computed in the above manner, the work would be very laborious. It may be much simplified if the load which any transformer would be likely to carry can be represented by only a few load cycles. Temperature rise curves for various values of $K_1C_1\sigma$ can be drawn for each of these load cycles for the region near the maximum, such as is shown in Fig. 8 for equation 14. The curves in Fig. 8 are drawn in per cent of the steady load temperature rise corresponding to the variable component of heat flow.

The method of applying Fig. 8 may best be shown by an example.

Example 3

Compute the maximum hot-spot temperature rise of the transformer in Example 1 when carrying maximum loads of 100 per cent, 120 per cent, and 140 per cent of rating with the load cycle represented by equation 14.

The work may most conveniently be arranged in tabular form, saving considerable time, especially if a large number of transformers are to be computed.

The last column of the tabulation below is the sum of four quantities, the steady state and variable components of T_1 and T_2 respectively, for instance:

$$(26 \times 0.44) + (26 \times 0.56 \times 0.955) + (24.2) + (39 \times 0.38 \times 0.485)$$
$$= 11.4 + 13.9 + 24.2 + 7.2 = 56.7$$

The load cycle factors in the above tabulation are obtained by choosing the point on the time scale of Fig. 8 such that $\lambda_2 \times \Delta T_2 + \lambda_1 \times \Delta T_1$ is a maximum, λ_2 being chosen on the temperature rise curve for $K_2C_2 = 0.15$ and λ_1 on the curve for $K_1C_1\sigma$ in the tabulation.

The most practical method of choosing this point is by trial and error, which is not difficult since the time for maximum hot-spot rise above ambient is not critical. In the foregoing tabulation it was not necessary to choose different times for the three loads computed. In general, the time of the maximum temperature rise for any given load cycle will not vary more than 10 minutes in self-cooled transformers with widely different characteristics.

From the data given in this last column, a curve of temperature rise versus load may be plotted and ratings for various ambient temperatures and load cycles determined therefrom. Curves of rating versus ambient temperature for the three load cycles of Fig. 6 and for continuous load are shown in Fig. 9.

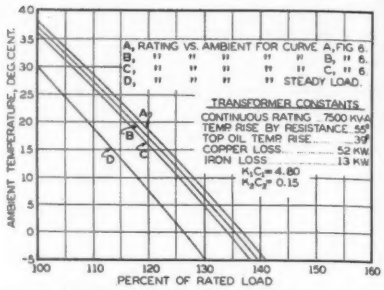
A, RATING VS. AMBIENT FOR CURVE A, FIG. 6
B, " " " " " B, " 6.
C, " " " " " C, " 6.
D, " " " " " STEADY LOAD.
TRANSFORMER CONSTANTS
CONTINUOUS RATING 7500 KVA
TEMP RISE BY RESISTANCE 55°
TOP OIL TEMP RISE 39°
COPPER LOSS 52 KW
IRON LOSS 13 KW
K_1C_1 = 4.80
K_2C_2 = 0.15
AMBIENT TEMPERATURE, DEG. CENT.
PERCENT OF RATED LOAD

Fig. 9—Ratings v. s. Ambient for Typical Transformer.

Water-Cooled Transformers

The dotted lines of Fig. 1 indicate the modifications necessary in the thermal circuit of a transformer when water cooling is added. With the ordinary steady state tests available it would be impossible to separate the component parts of the thermal capacity shown in the figure: C_1, C_3, and C_4. However, if the ambient air and ambient water temperatures are nearly equal as they usually are if average ambients are assumed, the effect of C_4 becomes small and the thermal circuit may be simplified by short-circuiting C_4 and adding C_1 and C_3 to equal the total thermal capacity of the transformer from oil to ambient. The equivalent thermal resistance K_3 from oil to incoming water is the ratio of oil temperature rise above incoming water divided by Q_3 which is determined by the rate of water flow and temperature difference between outgoing and incoming water. The value of K_3 determined in this manner may be considered to be very nearly constant. The remainder of heat flow Q_1 is the amount of heat flowing into the ambient air. The value of K. is determined by the same method as for self-cooled transformers and may most easily be obtained by reading the oil temperature of the transformer without water flowing, at a load such that the oil temperature is the same as rated load temperature when water is flowing, and dividing by the total heat flow at this load. If it is not practicable to obtain K_3 at this load, it may be corrected by application of a factor σ obtained from Fig. 4.

% Rated Load	Ultimate T_2 %	Ultimate T_2 Deg.	Ultimate T_{av} from Fig. 5 %	Ultimate T_{av} from Fig. 5 Deg.	Ultimate T_m from Fig. 5 %	Ultimate T_m from Fig. 5 Deg.	Per Cent ΔT_1
100	100	26.0	62.0	24.2	100	39.0	38.0
120	144	37.5	76.0	29.6	128	50.0	52.0
140	196	51.0	91.5	35.7	158	61.6	66.5

% Rated Load	σ from Fig. 4	$K_1C_1\sigma$	Load Cycle Factors from Figure 8 λ_2	Load Cycle Factors from Figure 8 λ_1	$\lambda_2 \times \Delta T_2$ Deg.	$\lambda_1 \times \Delta T_1$ Deg.	Total Hot-Spot Temp. Rise
100	0.844	4.05	0.955	0.485	13.9	7.2	56.7
120	0.800	3.84	0.955	0.505	20.1	10.2	76.4
140	0.760	3.65	0.955	0.525	27.3	13.6	99.0

An equation may be derived similarly to equation 12 for the temperature rise of a water-cooled transformer based on its simplified thermal circuit as explained above. This equation is derived in appendix C and given as follows:

$$\frac{t}{K_3C} = \frac{T_1}{K_3Q}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{1!}{mn+1}\left(\frac{T_1^n}{K_1Q}\right)^m + \frac{T_1^2}{K_3^2Q^2}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+1)!}{m!\,(mn+2)}\left(\frac{T_1^n}{K_1Q}\right)^m$$

$$+ \frac{T_1^3}{K_3^3Q^3}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+2)!}{m!2!\,(mn+3)}\left(\frac{T_1^n}{K_1Q}\right)^m + \frac{T_1^4}{K_3^4Q^4}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+3)!}{m!3!\,(mn+4)}\left(\frac{T_1^n}{K_1Q}\right)^m$$

$$+ \ldots\ldots\ldots\ldots$$

Where $C = C_1 + C_3$ (26)

$Q = Q_1 + Q_3$

$T_1^n = K_1Q_1$ in steady state. (27)

$T_1 = K_3Q_3$ in steady state. (28)

The above series, although complicated, is convergent and may be computed for various values of T_1/K_3Q and T_1/K_1Q on a percentage basis as was done for equation 12 to obtain the time scale for Fig. 3. As an example for $\frac{T_1}{K_3Q} = 0.330$, ratio of K_1/K_3 equal to 1, and n = 1.25, equation 26 becomes:

$$\frac{t}{K_3C} = 0.3300\left(1 + \frac{0.25}{2.25} + \frac{0.0625}{3.50} + \frac{0.0156}{4.75} + \frac{0.0039}{6.00} + \ldots.\right)$$

$$+ 0.1089\left(\frac{1}{2} + \frac{0.50}{3.25} + \frac{0.1875}{4.50} + \frac{0.0625}{5.75} + \frac{0.0195}{7.00} + \ldots.\right)$$

$$+ 0.0359\left(\frac{1}{3} + \frac{0.75}{4.25} + \frac{0.3750}{5.50} + \frac{0.1563}{6.75} + \frac{0.0586}{8.00} + \ldots.\right)$$

$$+ 0.0119\left(\frac{1}{4} + \frac{1.00}{5.25} + \frac{0.6250}{6.50} + \frac{0.3125}{7.75} + \frac{0.1367}{9.00} + \ldots.\right)$$

$$+ 0.0039\left(\ldots\ldots\ldots\right) + \ldots\ldots\ldots$$

On the basis of the above equation, various time scales may be constructed for the chart of Fig. 3 which may be used for any value of the ratio K_1/K_3. Computations have been made for the purpose of constructing these time scales and the results shown in the table as follows:

TABLE I

Per cent of Temperature Rise for all Water Cooling (No Air Cooling)

Time in Minutes	K_1/K_3 1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0
10	14.7	14.8	14.9	15.0	15.1	15.1	15.2	15.3	15.4
20	25.6	26.1	26.4	26.6	26.8	27.0	27.2	27.4	27.6
30	33.6	34.4	35.1	35.6	36.0	36.3	36.8	37.2	37.7
40	39.4	40.8	41.8	42.5	43.1	43.6	44.5	45.2	46.1
50	43.5	45.4	46.7	47.8	48.6	49.3	50.6	51.5	52.7
60	46.6	48.7	50.3	51.8	52.9	53.7	55.4	56.6	58.0
80	49.8	52.5	54.9	57.1	58.5	59.8	62.3	63.7	65.5
100	50.9	54.1	57.1	59.8	61.9	63.6	66.5	68.3	70.4
120	51.3	54.9	58.2	61.2	63.7	65.8	69.0	71.3	73.7
150	51.9	55.9	59.4	62.4	65.0	67.3	71.1	73.9	77.1
200	52.7	57.1	60.9	64.0	66.7	68.9	73.0	76.5	80.7
	53.8	58.6	62.4	65.5	68.3	70.6	75.1	78.4	83.0

From the above time scales the temperature rise curves for water-cooled transformers for all loads may be computed with a knowledge of the steady state oil rise obtained from equations 27 and 28. It would not be practicable in this case to construct a chart similar to Fig. 5 for this purpose on account of the number of variables involved.

For cyclic loading the same method may be used as for self-cooled transformers, obtaining ΔT from equations 27 and 28 and computing the temperature cycle between the limits of ΔT, assuming a linear thermal circuit in this range of temperature.

Conclusions

The preceding paragraphs demonstrate that it is quite feasible to calculate transformer temperatures under any loading condition which may be encountered and to calculate ratings such that given temperature limits will not be exceeded for any load cycle. These computations are all based on manufacturers' test data taken indoors in still air. Transformers located outdoors operate under conditions more favorable than this and hence will run cooler than calculated on the above basis. This may be considered as a factor of safety in the assigning of ratings to transformers operating outdoors.

Additional factors of safety must be applied if the transformer is operated in buildings or vaults. The best method of obtaining the ratings of transformers located in buildings or vaults is to record the actual building or vault temperature while the transformer is carrying a given load. This may be interpreted as an additional thermal resistance between transformer ambient and outside air.

Referring to the curves in Fig. 9, typical for a modern transformer, it can be said in general that when loaded with the load cycles commonly met with, self-cooled transformers of good thermal design can be rated approximately 10 per cent more than if loaded with a continuous constant load. Somewhat lesser increases in loading can be expected for water-cooled transformers under cyclic loading. These increases in rating can be used to good advantage by the electric light and power industry in decreasing investment in transformers.

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APPENDIX A

List of Symbols

C_1 = Equivalent thermal capacity of oil, core, and case.
C_2 = Thermal capacity of windings.
$C = C_1 + C_2$ in water-cooled transformers (See figure 1).
I = Iron Loss = $Q_1 - Q_2$.
K_1 = Thermal resistance from ambient to oil.
K_2 = Thermal resistance from oil to windings.
K' = Modified average value of thermal resistance = K.
N = Harmonic number.
n = Exponent showing variability of thermal resistance.
p = Operator denoting differential, $\frac{d}{dt}$
Q_1 = Steady state heat flow from oil to ambient.
Q_2 = Steady state heat flow from windings to oil.
Q_3 = Steady state heat flow from oil to water in water-cooled transformers.
$Q = Q_1 + Q_2$ in water-cooled transformers.
q_1 = Instantaneous heat flow from oil to ambient.
q_2 = Instantaneous heat flow from windings to oil.
q_m = Maximum value of q_1.
T_1 = Temperature rise of oil above ambient.
T_2 = Temperature rise of windings above oil.
T_m = Maximum value of T.
T_{av} = Average value of T.
$T_{(t)}$ = Value of T at time t.
T_o = Initial temperature rise.
t = Time expressed in hours.
ϵ = Naperian constant = 2.7183.
σ = Correction factor for non-linear thermal circuit.
ω = Angular velocity of heat flow and temperature vectors.
λ_1 = Load cycle factor for ΔT_1.
λ_2 = Load cycle factor for ΔT_2.

APPENDIX B

Calculation of Thermal Capacity

The thermal capacity of a transformer is a difficult quantity to accurately calculate. The method described in reference 3, and briefly demonstrated below is used in this paper.

If the weight of the windings is expressed in pounds, the thermal capacity, in kilowatthours per degree Cent., of the thermal circuit from oil to copper is given by the following equation:

$C_2 = 4.93 \times 10^{-5} \times$ (weight of windings)

In the above equation, the total weight of the copper and winding insulation is included as the weight of the windings and assumes that the specific heat of the total winding is the same as that of the copper. The weight of the insulation is such a small part of the total winding weight that the error is small in making this assumption.

Expressing the weight of the oil, core, and tank in pounds, the thermal capacity in kilowatthours per degree Cent. of the thermal circuit from oil to copper is given by the following equation:

$C_1 = 6.0 \times 10^{-5} \times$ (weight of core + 2/3 weight of tank) $+ 23.7 \times 10^{-5} \times$ (0.85 x weight of oil)

where 0.85 = factor, $\frac{\text{average oil temperature}}{\text{top oil temperature}}$

and 2/3 = factor, $\frac{\text{average tank temperature}}{\text{top oil temperature}}$

0.237 = specific heat of transformer oil
0.0493 = specific heat of copper
0.060 = specific heat of iron

in watthours per pound.

APPENDIX C

(1) Heating curve of self-cooled transformer windings above ambient when heat flow is linear with temperature; solution of the differential equations:

$$T_1 = K_1\left(Q_1 - \frac{dq_1}{dt} - \frac{dq_2}{dt}\right) \quad (2)$$

$$T_2 = K_2\left(Q_2 = \frac{dq_2}{dt}\right) \quad (3)$$

$$\frac{1}{C_1}\left(\frac{dq_1}{dt}\right) = \frac{dT_1}{at} \quad (4)$$

$$\frac{1}{C}\left(\frac{dq_2}{dt}\right) = \frac{dT_2}{dt} \quad (5)$$

Then $T_1 = K_1\left(Q_1 - C_1\frac{dT_1}{dt} - C_2\frac{dT_2}{dt}\right)$

$$T_2 = K_2\left(Q_2 - C_2\frac{dT_2}{dt}\right)$$

or $T_1(1 + K_1C_1p) + K_1C_2pT_2 = K_1Q_1$

$T_2(1 + K_2C_2p) = K_2Q_2$

$$T_1(1 + K_1C_1p) + \frac{K_1C_2K_2Q_2p}{1 + K_2C_2p} = K_1Q_1$$

$$T_2 = \frac{K_2Q_2}{1 + K_2C_2p}$$

$$T_1 = \frac{1}{K_1K_2C_1C_2}\left\{\frac{K_1Q_1(1 + K_2C_2p) - K_1K_2C_2Q_2p}{\left(\frac{1}{K_2C_2} + p\right)\left(\frac{1}{K_1C_1} + p\right)}\right\}$$

$$= \frac{1}{K_1K_2C_1C_2}\left\{\frac{K_1Q_1 + (Q_1 - Q_2)K_1K_2C_2p}{\left(\frac{1}{K_2C_2} + p\right)\left(\frac{1}{K_1C_1} + p\right)}\right\}$$

This is of the form

$$T_1 = ab\left(\frac{c + dp}{(a + p)(b + p)}\right)$$ whose solution is:

$$T_{1(t)} = c + \frac{abc}{b-a}\left(\frac{\epsilon^{-bt}}{b} - \frac{\epsilon^{-at}}{a}\right) + \frac{abd}{a-b}\left(\epsilon^{-bt} - \epsilon^{-at}\right)$$

where $a = \frac{1}{K_1C_1}$

$$b = \frac{1}{K_2C_2}$$

$$c = K_1Q_1$$

$$d = K_1K_2C_2I$$

$$c - bd = K_1Q_1 - K_1I = K_1Q_2$$

$$c - ad = K_1Q_1 - K_2\left(\frac{C_2}{C}\right)I$$

$$I = Q_1 - Q_2$$

Hence —

$$T_{1(t)} = K_1Q_1\left\{1 - \epsilon^{-\frac{1}{K_1C_1}t}\right\} + \frac{K_1C_2K_2Q_2}{K_1C_1 - K_2C_2}\left\{\epsilon^{-\frac{1}{K_2C_2}t} - \epsilon^{-\frac{1}{K_1C_1}t}\right\} \quad (6)$$

$$T_{2(t)} = K_2Q_2\left\{1 - \epsilon^{-\frac{1}{K_2C_2}t}\right\} \quad (7)$$

(2) Heating curve of self-cooled transformer where heat flow in the steady state is expressed by the equation—

$$T^n = KQ.$$

Then $T^n = K\left(Q - \frac{dq}{dt}\right)$ (10)

$$= K\left(Q - C\frac{dT}{dt}\right)$$

$$\frac{dT}{dt} = \frac{1}{C}\left(Q - \frac{T^n}{K}\right)$$

Hence $\left(\frac{1}{KQ - T^n}\right)dT = \frac{1}{KC}\,dt$

Expand $\frac{1}{KQ - T^n}$ in series form and it becomes:

$$\frac{1}{KQ}\left\{1 + \frac{T^n}{KQ} + \left(\frac{T^n}{KQ}\right) + \left(\frac{T^n}{KQ}\right)^3 + \ldots.\right\}$$

$$= \frac{1}{KQ}\sum_{\substack{m=o\\m=k}}^{m=\infty}\left(\frac{T^n}{KQ}\right)^m$$

where k is any positive integer.

Integrating,

$$\int_{T_o}^{T}\frac{1}{KQ}\sum_{\substack{m=o\\m=k}}^{m=\infty}\left(\frac{T^n}{KQ}\right)^m dT = \frac{1}{KC}\int_{o}^{t} dt$$

or

$$\frac{T}{KQ}\sum_{m=o}^{m=\infty}{}_{m=k}\left(\frac{T^n}{KQ}\right)^m\left(\frac{1}{mn+1}\right)-\frac{T_o}{KQ}\sum_{m=o}^{m=\infty}{}_{m=k}\left(\frac{T^n_o}{KQ}\right)^m\left(\frac{1}{mn+1}\right)=\frac{t}{KC}$$

Expanded in series form the above equation becomes:

$$\frac{t}{KC}=\frac{T}{KQ}\left\{1+\frac{1}{n+1}\left(\frac{T^n}{KQ}\right)+\frac{1}{2n+1}\left(\frac{T^n}{KQ}\right)^2+\frac{1}{3n+1}\left(\frac{T^n}{KQ}\right)^3+\ldots.\right\}$$
$$-\frac{T_o}{KQ}\left\{1+\frac{1}{n+1}\left(\frac{T^n_o}{KQ}\right)+\frac{1}{2n+1}\left(\frac{T^n_o}{KQ}\right)^2+\frac{1}{3n+1}\left(\frac{T^n_o}{KQ}\right)^3+\ldots.\right\} \qquad (11)$$

(3) Heating curve of water-cooled transformer where heat flow in steady state is expressed by the equations:

$$T^n = K_1Q_1$$
$$T = K_2Q_2$$

Hence total heat flow from oil to air and water is—

$$Q_1+Q_2=\frac{T^n}{K_1}+\frac{T}{K_2}=Q$$

Then for the transient state similarly derived as in (2) above—

$$\frac{1}{Q}\left\{\frac{1}{1-\frac{T^n}{K_1Q}-\frac{T}{K_2Q}}\right\}dT=\frac{1}{C}\,dt$$

Hence $$\frac{1}{K_2Q}\sum_{m=o}^{m=\infty}{}_{m=k}\left(\frac{T^n}{K_1Q_1}+\frac{T}{K_2Q}\right)^m dT=\frac{1}{K_2C}\,dt$$

Integrating for the case of zero initial load:

$$\frac{1}{K_2Q}\int_o^T\left(\frac{T^n}{K_1Q}+\frac{T}{K_2Q}\right)^m dT=\frac{1}{K_2C}\int_o^t dt$$

or $$\frac{T}{K_2Q}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{1!}{mn+1}\left(\frac{T^n}{K_1Q}\right)^m+\frac{T}{K_2^2Q^2}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+1)!}{m!\,(mn+2)}\left(\frac{T^n}{K_1Q}\right)^m$$
$$+\frac{T^3}{K_2^3Q^3}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+2)!}{m!2!\,(mn+3)}\left(\frac{T^n}{K_1Q}\right)^m+\frac{T^4}{K^4_2Q^4}\sum_{m=o}^{m=\infty}{}_{m=k}\frac{(m+3)!}{m!3!\,(mn+4)}\left(\frac{T^n}{K_1Q}\right)^m$$
$$+\ldots.=\frac{t}{K_2C}$$

All Power Companies Invited to Compete for Coffin Award

INVITATIONS have been extended by the Prize Awards Committee, Frank W. Smith, Chairman, to all electric light and power companies operating in the United States to compete for the Charles A. Coffin Medal for 1937.

Under the terms of the Charles A. Coffin Foundation as established by the General Electric Company, the Charles A. Coffin Award will be made to that company which during the year 1936 has made a distinguished contribution to the development of electric light and power for the convenience of the public and the benefit of the industry.

Presentations of accomplishments by companies desiring to compete for the award are to be made not later than April 1, 1937. The presentation of the award will be made at the 1937 Convention of the Institute.

In addition to the Charles A. Coffin Medal, the award carries with it a gift of one thousand dollars for the employees' benefit fund of the winning company.

The Committee of Judges for the Charles A. Coffin Award consists of Charles W. Kellogg, President of the Edison Electric Institute; Karl Taylor Compton, President of the Massachusetts Institute of Technology, and Mr. Smith, Chairman, Prize Awards Committee.

The terms of the Coffin Award in calling for a "distinguished contribution" to the industry, indicate an accomplishment requiring an important decision or action in the field of policy, the invitation states. A statement of such outstanding accomplishment, it is suggested, should be made the basis and principal feature of the presentation by companies competing for the award. Such a major contribution, dedicated to the convenience of the public and beneficial to the industry, will ordinarily be reflected in the operations of various departments of management. The following subjects, and any other appropriate items, may be presented as contributory evidence in support of the principal accomplishment upon which the exhibit is based:

Financial operations as reflected by the company's balance sheet and income statement.
Production and sales of electric energy.
Rate developments.
Important changes in company administration for increased efficiency.
Employee relations.
Relations with consumers and the public.
Increased usage of electric energy and revenue.
Promotional and sales programs.
Co-operative sales development.
Financing plans.
Advertising programs.
Trade relations.
Rural electrical development.
Credit and collection methods.
Accounting developments.
System operation.
Reliability of service.
Generation, transmission, distribution and construction designs and practices.
Accident prevention.

For having made a distinguished contribution to the development of electric light and power for the convenience of the public and the benefit of the industry, awards of the Charles A. Coffin Medal have been made to

Southern California Edison Company for 1922.
Public Service Company of Northern Illinois for 1923.
Consumers Power Company for 1924.
Commonwealth Edison Company for 1925.
Edison Electric Illumination Company of Boston for 1926.
Puget Sound Power and Light Company for 1927.
El Paso Electric Company for 1928.
Public Service Electric and Gas Company for 1929.
Virginia Electric and Power Company for 1930.
(No Awards made in 1931 and 1932).
The Hartford Electric Light Company for 1933.
The Tennessee Electric Power Company for 1934.
Idaho Power Company for 1935.

PRIZES

to be administered by the

EDISON ELECTRIC INSTITUTE

AND AWARDED IN 1937

PRIZES TO INDIVIDUALS

For Papers on Subjects Relating to the Electric Light and Power Industry

BYLLESBY PRIZE . . . . . *Accounting*

Cash prizes of $100, $50 and $25 donated by Public Utility Service Corporation, in memory of Colonel H. M. Byllesby, for the three most meritorious papers on any Accounting subject relating to the Electric Light and Power Industry.

FORBES PRIZE . . . . . *Public Relations*

A cash award of $250 donated by Mr. B. C. Forbes, Editor, Forbes Magazine, for the most meritorious paper dealing with the subject of Public Relations in the Electric Light and Power Industry.

LINDEMANN PRIZE . . . *Electric Cookery*

Cash prizes of $150, $100 and $50 donated by Mr. A. L. Lindemann, President, A. J. Lindemann and Hoverson Company, for the three most meritorious papers dealing with the Advantages of Electric Cookery for Domestic Purposes.

McGRAW PRIZE . . . . . *Engineering*

Cash prizes of $250, $150 and $100 donated by Mr. James H. McGraw, Honorary Chairman, McGraw-Hill Publishing Company, for the three most meritorious papers on any Engineering or Technical subject relating to the Electric Light and Power Industry.

RULES AND CONDITIONS OF CONTESTS FOR PRIZES TO INDIVIDUALS

Any person employed by an electric light and power company is eligible to enter the competition. No person is eligible to win two years in succession the identical prize or lower prize of the same award, but is eligible for a higher prize of that award. Papers must be the original work of the author or authors, prepared exclusively for this competition. Papers may be of any length, and pen-and-ink drawings or photographs suitable for reproduction may be included. Papers should be typewritten on one side only.

Papers will not be returned to contestants, but will become the property of the Edison Electric Institute and will be available for inspection at the General Offices of the Institute. The right is reserved to publish any paper entered in the contest.

The first page of the manuscript must give the following information: the name of the prize for which the paper is submitted, title of paper, name of author, name and address of employing company, title or character of position and home address. One paper may not be submitted for more than one prize.

PAPERS FOR ABOVE PRIZES MUST BE FORWARDED, IN DUPLICATE, BY MARCH 1, 1937

PRIZES TO COMPANIES AND INDIVIDUALS

For Accomplishments in Specified Activities

CHARLES A. COFFIN AWARD

Sponsored by the General Electric Company

A Gold Medal, known as the Charles A. Coffin Medal, will be awarded to the public utility operating company within the United States which, during the year 1936, has made a distinguished contribution to the development of electric light and power for the convenience and well being of the public and the benefit of the industry. The company awarded the medal will also receive $1,000 for its employes' benefit or similar fund.

AUGUSTUS D. CURTIS AWARD

Lighting of Buildings

A certificate donated by Messrs. Darwin Curtis and Kenneth Curtis, of Curtis Lighting, Incorporated, in memory of Augustus D. Curtis, to the public utility operating company within the United States which, during the twelve month period ending March 1, 1937, has shown the greatest contribution to the advancement of Artificial Illumination of interiors or exteriors of Commercial and Public Buildings, and a cash prize of $300 to the individual or individuals in that company responsible for the achievement. A second prize of $200 and a third prize of $100 to the individual or individuals responsible for the achievement of the companies adjudged second and third in the contest.

GEORGE A. HUGHES AWARD

Domestic Electric Cookery Load

A trophy donated by Mr. George A. Hughes, President, Edison General Electric Appliance Company, Inc., to the public utility operating company within the United States which, during the year 1936, has shown the greatest contribution to the development of the Domestic Electric Cookery Load through promotion, or selling, or both, and cash prizes totaling $1,000 to the individuals responsible for the achievement.

THOMAS W. MARTIN AWARD

Rural Electrification

A bronze plaque donated by Mr. Thomas W. Martin, President, Alabama Power Company, to the public utility operating company within the United States which, during the year 1936, has shown the greatest contribution to the advancement of Rural Electrification-Agricultural advancement within the company's territory due to uses of electricity, development of rural load, cooperation with other agencies, extension of rural lines, organization and plan for conducting rural electric development.

IMPORTANT—Complete details for the Charles A. Coffin Award, the Augustus D. Curtis Award, the George A. Hughes Award, and the Thomas W. Martin Award should be secured from the Secretary, Edison Electric Institute, 420 Lexington Avenue, New York, N. Y.

Elaborate and costly exhibits are unnecessary. The merit of the enterprise presented in papers or exhibits will be the prime factor in determining awards, without regard to the size of competing companies.

PRESENTATIONS OF ACCOMPLISHMENTS MUST BE FORWARDED BY APRIL 1, 1937

Papers and exhibits for 1937 prizes should be addressed to the Secretary, Edison Electric Institute, 420 Lexington Avenue, New York, N. Y. Winners will be announced and prizes awarded at the 1937 Convention of the Edison Electric Institute

PRIZE AWARDS COMMITTEE: Charles W. Kellogg, James E. Davidson, Frank W. Smith, *Chairman*, M. T. Chandler, *Secretary*

Prime Movers Committee Meeting

P. W. Thompson, Chairman

THE Winter meeting of the Prime Movers Committee was held Nov. 30, and Dec. 1, at the general offices of the Institute, New York City.

Organization of Subcommittee reports for the coming year was the primary business of the meeting. The Chemists Subcommittee circulated a memorandum on the use of chloramines for slime control in condensers and proposed a questionnaire covering the measurement of "creep" in equipment actually installed for high temperature service.

Professor Straub of the University of Illinois reported his recent work concerning the stability of sodium sulphite at temperatures ranging from 500° F. to 600° F. Mr. Straub's talk was followed by an extended discussion of boiler feed water treatment, including the use of finely divided iron for removal of dissolved oxygen.

Mr. Krieg reported progress in the preparation of station data sheets which will be ready for distribution soon, including cross sections of some of the new boilers and turbines. A tentative arrangement has been made to publish several heat balance diagrams in *Combustion* magazine for January and perhaps others in subsequent issues.

In discussing the work of the Boilers Subcommittee, Mr. Caldwell presented a form on which boiler availability data is to be recorded. It was brought out in the discussion that the Subcommittee is interested particularly in availability records where the boiler is needed nearly all the time so that the record will show what can be done when there is a real incentive to keep the boiler on the line.

Mr. Muir outlined the plans to the Combustion Subcommittee with particular emphasis on superheat control, water cooled stokers, slag tap furnaces and on the preparation and storing of coal. In this connection Mr. Thompson indicated that some results on the burning of blast furnace gas at Delray would be available in March.

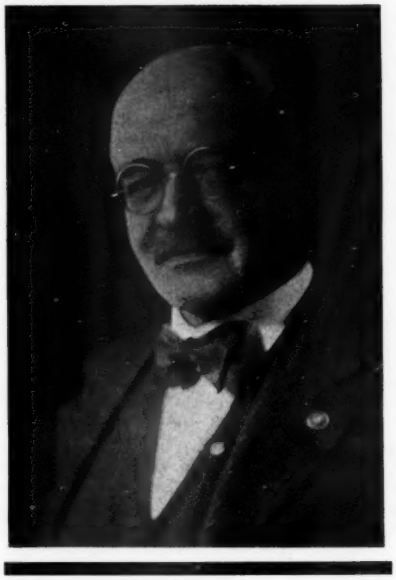
It was decided that the operating data on Diesel engine plants was of such importance to the committee that Mr. Elliott of the Oil and Gas Engines Subcommittee would again collect the necessary data and report on the cost of operation of Diesel engine plants as in previous years. Mr. Hardy gave some preliminary information concerning an engine to be installed in Texas to operate normally on natural gas but convertible for the use of oil in a few hours.

There was a brief discussion of methods of cleaning pulverized fuel mills, piping, and bins as they are being taken out of service, recommendations being made as to procedure for minimizing hazard of dust explosions. Various methods now in use include the use of steam, flue gas, and an air water mixture like a heavy fog introduced into the mills and bins to render the space inert against explosions.

The Committee adjourned to permit a number of the members to visit the plant of M. W. Kellogg to witness pipe bending and welding procedure.

Charles J. Russell

CHARLES JACOB RUSSELL, Vice-President in Charge of Rates and Standard Practice, Philadelphia Electric Company, died on December 8 at his home, 5003 Penn Street, after an illness of several months. The funeral



services were held on Friday, December 11, with interment in the Forest Hills Cemetery, Somerton, Pa. Mr. Russell was the second oldest active employee of the company, entering its employ in December, 1890.

Mr. Russell was one of the pioneers of the electric industry. His career extended across the period of the great development of electric light and power. He started in at the age of 21, with Fuller Holtzer, afterwards Fuller, Holtzer and Cabot, as an electrician. From this post he advanced in four years to be superintendent of the firm's electric light and power departments when the firm became the Holtzer Cabot Electric Company.

In 1890 he became superintendent of the Manufacturers Electric Company, one of the early companies engaged in the supply of electric light and power service in Philadelphia, and a predecessor of the Philadelphia Electric Company. In 1898 he was advanced to the post of superintendent and electrical engineer of the Manufacturers Electric and Suburban Electric Company, where he continued until 1915, when he was again advanced, this time to be manager of the Sales Departments of the Philadelphia Electric Company. His next rise came in 1918, when he was appointed General Commercial Manager. He was made vice-president in charge of Commercial Departments in 1922. On November 21, 1928, he became Vice-President in Charge of Rates and Standard Practice, the position he held at the time of his death.

Mr. Russell was born March 10, 1864, in Waterford, Maine. He received an academic education in New England schools and instruction in mechanical, electrical, civil and hydraulic engineering from polytechnic schools in France and Belgium. He also studied electricity and chemistry at the Lawrence Scientific School and received instruction in physical and electrical measurements from the Massachusetts Institute of Technology.

Mr. Russell was a member of the American Institute of Engineering; British Institute of Electricity; French Institute; original and sole member of the American Committee on steel tower conferences; charter member of the Illuminating Engineering Society and American Electric & Chemical. He had been chairman and member of committees of the former National Electric Light Association and of the Edison Association, dealing with rate power applications and service. In 1909 he was awarded the first Doherty Gold Medal on his work of power factor diversity.

New Reports of Joint Subcommittee on Development and Research

Volumes III and IV of Engineering Reports of the Joint Subcommittee on Development and Research—Edison Electric Institute—Bell Telephone System—Price each $10.00—To Members $5.00.

THESE volumes are a continuation of the series of reports giving the results of the work of the Joint Subcommittee on Development and Research to date. Volume I, published in 1930, contained reports 4 to 8 inclusive and Volume II, published in 1932, contained reports 9 to 15 inclusive. At this time the accumulated reports require two volumes for publication, so that Volume III contains reports 16 to 25 inclusive and Volume IV contains reports 26 to 38 inclusive. The reports in these two volumes, in addition to consisting of certain fundamental material, include many formulas and curves necessary for calculations in the ordinary run of inductive coordination problems. The use of this material by the engineers of operating power and telephone companies will not only greatly assist the solution of inductive coordination problems but should in many cases substantially reduce the cost necessary to obtain satisfactory coordination. The contents of the volumes are as follows:

VOLUME III

Report No. 16—A Method of Estimating Noise in Open-Wire Toll Circuits. Formulas, together with charts and tables of numerical values, are given for estimating noise in open-wire telephone toll circuits in situations of proximity to power lines. The report discusses the use of this material in the study of projected exposures and in the determination of the relative importance of the various factors in noise induction.

* * *

Report No. 17—Short-Cut Methods for Estimating Noise in Open-Wire Subscriber Circuits Exposed to Power Lines at Roadway Separations. This treatment for exposures at roadway separations is an extension of that contained in Report No. 13 (Vol. II) for joint use conditions.

* * *

Report No. 18—Longitudinal-Circuit Propagation Along Open-Wire Lines at Voice Frequencies. A method is presented for calculating the propagation of noise frequency currents and voltages in a circuit composed of a number of wires in parallel with return through the ground.

* * *

Report No. 19—Direct Capacitances and Capacitance Unbalances in Open-Wire Telephone and Joint-Use Lines. This report includes reference tables of capacitances for selected systems of wires for a telephone line alone and for a telephone line on joint use poles with power conductors. The usefulness of these data in studies of shielding in electric induction is briefly discussed.

* * *

Report No. 20—Exploring Wire Methods for Toll and Local Circuit Noise Studies. Methods are described for obtaining information on the various components of power circuit voltages and currents without making measurements in the power lines. Reference is made to the application of these methods in studying the relative importance of various harmonics or the variations in influence with time and location.

* * *

Report No. 21—Selective Devices for Reducing Harmonics in D-C Power Systems. This report describes the design and application of a number of selective devices suitable for reducing harmonic or "ripple" voltages and currents in d-c systems. Similar information for a-c systems is given in Report No. 34 (Vol. IV).

* * *

Report No. 22—Wave-Shape Characteristics of Power Circuits Supplying Rectifiers. The results of an extensive study of the factors influencing the wave shape of a-c systems supplying rectifiers is given, together with a method of estimating the magnitudes of harmonic voltages and currents introduced by rectifiers. A discussion of possible coordinative measures is included.

* * *

Report No. 23—Impedances of A-C Supply Systems at Harmonic Frequencies to Balanced Components. This report discusses methods of estimating the harmonic frequency phase-to-neutral impedances of a power system. The necessary formulas are given, together with a summary of the data required in calculating the equivalent impedances of overhead and cable circuits, transformers, reactors, voltage regulators and various types of rotating machinery.

* * *

Report No. 24—Impedance of A-C Supply Systems at Harmonic Frequencies to Residual Components. Harmonic frequency impedances-to-residuals are treated in a manner similar to that for phase-to-neutral impedances in Report No. 23.

* * *

Report No. 25—Articulation Studies on the Effects of Noise. This report contains the results of an investigation of the effects of noise in telephone circuits conducted by the articulation testing method. Particular attention is devoted to the adequacy of methods of measuring noise.

* * *

VOLUME IV

Report No. 26—Shielding of Ground-Return Circuits at Low Frequencies. The factors which control the magnitude of shielding are considered, and the principles developed are applied to practical cases. A large number of figures are included, giving formulas, data, or working curves to facilitate the solution of problems of shielding from induction due to fault currents in power circuits.

* * *

Report No. 27—General Considerations in the Use of Neutral Impedance. The report discusses factors requiring consideration in proposed applications of neutral impedance in power systems as a means of reducing voltage along exposed communication circuits at times of power system faults to ground. Matters covered include former and current neutral grounding practice, overvoltages, insulation levels, relaying, and efficacy of neutral impedance in reducing induced voltage.

* * *

Report No. 28—The Effect of Vacuum Tube Amplifiers and Telephone Repeaters on Acoustic Shock. The nature of the reduction in acoustic shock effected by vacuum tube amplifiers and telephone repeaters is explained. Information is given from which estimates may be made of the reduction available from repeaters.

* * *

Report No. 29—Use of Copper Oxide Varistors in Reducing Acoustic Shock. A copper-oxide device for reducing acoustic shock is described, and the results obtained in laboratory tests and field trials are discussed.

* * *

Report No. 30—Overvoltages on Transmission Lines Due to Ground Faults as Affected by Neutral Impedance. Based on extensive field observations collected over a period of several years, overvoltages due to phase-to-ground faults are discussed from the standpoint of magnitude and frequency distribution under different grounding conditions.

* * *

Report No. 31—Low Resistance Grounds. This report discusses various factors in the installation and measurement of low resistance grounds, including: kind of electrode, treatment of soil, location of electrode, physical features of construction, paralleling efficiency and seasonal variation.

* * *

Report No. 32—Relative Interfering Effects of Different Single Frequency Noises in Telephone Circuits. Revised values for the relative interfering effects of different frequencies of noise on a telephone circuit are given, together with a discussion of the test results from which they were derived.

* * *

Report No. 33—The Telephone Influence Factor of Supply System Voltages and Currents. Based on the information contained in Report No. 32 a new frequency weighting characteristic is derived for the Telephone Influence Factor (TIF). The significance and usefulness of this quantity is reviewed, and methods of measuring and calculating it are described.

* * *

Report No. 34—Selective Devices for Reducing Harmonics on Power Systems—Part

II A-C Systems. The treatment of selective devices for a-c power systems is similar to that for d-c systems in Report No. 21. (Vol. III.)

* * *

Report No. 35—Study of Observations from Low Frequency Inductive Exposure. This report presents an analysis of data relative to low-frequency induction due to power system ground-fault currents, obtained from oscillographic observations and related records from 29 exposures. The magnitude and magnitude distribution of observed voltages and their comparison with estimated values are presented, together with available data as to the effects of such voltages.

* * *

Report No. 36—The Use of Power and Telephone Transpositions Within Exposure Sections. A discussion of the principles of the application of power and telephone transpositions to reduce noise induction in exposed sections is given, together with test results for various combinations of power and telephone transpositions.

* * *

Report No. 37—Computation of Zero-Sequence Impedances of Power Lines and Cables. Formulas are developed for computing zero-sequence impedance and ground-wire or sheath currents of power lines and cables. Charts and tables are provided to facilitate computations.

* * *

Report No. 38—Power Level and Sensitivity of Telephone Circuits. This report gives a general discussion of power levels in telephone circuits of the Bell System, from the standpoint of the relationship between these levels and the susceptiveness of the circuits to noise induction from power circuits.

The material contained in the above reports is such that it can readily be used by engineers working on the coordination of power and communication circuits. Many of these reports have been available for some time in mimeograph form and have been extensively used by power company engineers in connection with their daily work. A considerable part of the basic material contained in these volumes, and not available from other sources, is of considerable aid in the design and operation of the power system itself.

YOUR UNSEEN HELPER

THE PROPER CARE OF YOUR ELECTRICAL DEVICES AND WIRING

PORTABLE EXTENSION LIGHTS— should be equipped with porcelain or moulded composition sockets. The lamps should be protected against breakage by using a suitable guard. Extra heavy cord with water-proof covering is recommended for use in damp places. Kinking or bending the cord injures the protective covering. Repair or replace cords when they become worn.

SOCKETS— used in bathrooms, basements or other damp places should be of porcelain or moulded composition. A link of insulating material should be used in metal pull chains. Avoid touching metal sockets and electrical appliances while standing on a wet floor, while taking a bath, or touching radiators or other plumbing.

ELECTRIC IRONS — and other heating appliances in use, should be kept away from inflammable materials. Always place an electric iron on its stand or rest when not in use, and be sure to disconnect it from the source of supply. Misuse of lamps, irons or toasters for warming bedding is dangerous. Serious injury or fire may result from this practice.

FUSES— are electrical safety valves. Blowing one warns of overload or defective wiring or appliances. The fault cannot be corrected by inserting a larger size (over-rated) fuse. Always replace a blown fuse with one of proper rating. It is your protection against fires and accidents.

OUTDOOR RADIO AERIALS — should be placed away from power wires—not over or under them. An aerial which has fallen against power lines is probably alive, regardless of insulation on either or both. NEVER attempt repairs under such conditions. Call the Electric Light Company.

INSULATION—the protective covering on extension cords and electrical wiring is your protection against fires and shock. Cords, lamp sockets and appliances used in damp places, bathrooms, and around piping should be carefully and regularly inspected, and repaired if defective.

CONVENIENCE OUTLETS— should be installed for connecting portable appliances. Screw base receptacles are no longer satisfactory. They should be replaced, or permanently equipped with the screw base section of an attachment plug.

RADIOS — should be disconnected from the power supply before working on them. Changing connections, making adjustments within your set, or extending internal high voltage circuits outside your set may result in damage to the set or in electric shock.

PIPING— containing steam, gas, oil or water, particularly where near your electrical equipment, should be kept in good repair and free from leaks. Your electrical wiring should be protected against contact with water or oil.

FALLEN OVERHEAD WIRES— are usually the result of severe storms. Fallen wires may be alive. NEVER touch them. Notify the Electric Light Company and warn others of possible danger.

PERIODIC INSPECTIONS — of your electrical equipment by a responsible electrician will prevent the inconvenience and annoyance of failure of appliances, etc., when in use, and safeguard your electric service from possible interruptions caused thereby.

ADDITIONAL WIRING — on your premises should be installed only by a responsible electrician. Good wiring is your best insurance against fire and accidents.

INSURES SAFETY AND SATISFACTION

REPRODUCED above are the inside pages of the leaflet, "Your Unseen Helper", which was prepared by the Accident Prevention Committee of the Institute for use in the campaign to insure safety and satisfaction in the use of electrical devices and to avoid electric shock resulting from the misuse of defective appliances and wiring. The leaflet is designed to be used as an envelope stuffer by operating companies. It is printed in two colors and has space on the back cover for imprinting the name of the company distributing it. Sample copies of the leaflet will be sent upon application to the Edison Electric Institute, 420 Lexington Ave., New York, N. Y.

Since most of the accidents attributable to electrical appliances are the result of negligence or carelessness, the leaflet will be of value in impressing on users of electric service the necessity for common-sense treatment of their electrical equipment. The leaflet, incidentally, is a successor to and an enlargement of an earlier leaflet sponsored by the Accident Prevention Committee. Several million copies of the earlier leaflet were distributed.

RECENT E.E.I. PUBLICATIONS

AIR CONDITIONING—1936

E.E.I. Pub. D-12. A report of the Sales Committee, Edison Electric Institute, 58 pages. Price $1.20 to members and their employees; $3.00 to non-members in the U.S.A.; $3.15 to foreign countries.

This report contains factual data on air conditioning installations for personal comfort and for profit in many different types of buildings.

A plan for cooperation with the Air Conditioning Manufacturers' Association and a commercial definition of the minimum requirements of air conditioning is included.

Recent developments in attic ventilation and circulation of air in residences and residential year around air conditioning are discussed.

TURBINES, CONDENSERS, FEEDWATER HEATERS AND PUMPS—1936

E.E.I. Pub. D-11. A report of the Prime Movers Committee, Edison Electric Institute, 34 pages. Price 60c to members and their employees; $1.50 to non-members in the U.S.A.; $1.60 to foreign countries.

This report contains statements by Operating Companies and Manufacturers on:

Turbine Operating Data for year 1935.
New Turbine Installations.
Turbine Operating Experiences.
Metallizing of Turbine Parts.
Effect of Age on Turbine Efficiency.
Turbine Lubrication.
Condenser Tube Materials.
Chlorination of Circulating Water.
Feedwater Heaters.
Boiler Feed Pumps.

PENSTOCKS

E.E.I. Pub. D-15. A report of the Hydraulic Power Committee, Edison Electric Institute, 46 pages. Price $1.00 to members and their employees; $2.50 to non-members in the U.S.A.; $2.65 to foreign countries.

This report presents data on the progress since 1923 in the design and construction of penstocks, special connections and appurtenances. Pipes of unprecedented size and for use under greater heads have been built, and the use of fusion welded pipe and specials has developed greatly during this period. The technique in the design and production of large and thick walled conduits, forged from solid steel billets, has also been improved. New and interesting designs of wyes, branches, surge tank connections, slip joints, cradles and other accessories of pipe lines have been brought out.

Many novel designs and hitherto unpublished design data on tees and riveted joints are presented. The report has sections on:

General Design
Types of Construction
Details and Accessories
Testing and Maintenance
Manufacturer's Statements

Government Ownership: Theory vs. Experience

(*Continued from page* 480)

periments in municipal ownership and operation of electric utilities in the very heavy governmental subsidy involved, which is collected from the people of the nation as a whole for the benefit of specific communities. No doubt the gradual general public realization of what the process involves and how it works will make it a short-lived phenomenon in our national history. Municipal ownership, however, due to its theoretical appeal, and in many cases its apparent political value, is likely to spring up anywhere at any time.

To summarize—the question of municial ownership of the electric service in our cities has been emphasized by political pressure far beyond its true importance to the average citizen. As the present conditions show, after decades of experience with thousands of cities, the cost of electricity for the ordinary householder is but 2 per cent of his budget and, after allowing for the tax exemption which municipalities enjoy, household rates are actually higher with municipal than with private operation. That is the reason why the vast majority of cities and towns in our country are glad to leave to private companies the raising of the relatively large capital and the furnishing of high technical skill required by electric service, so as to conserve the credit of the city or town for those essential common needs like schools, streets and other public works which must of necessity be financed by the municipality. One can only conclude that the agitation for municipal ownership of electric utilities is kept up by those who see only the admittedly attractive theory but blind themselves to the patent facts of long and varied experience in this country.

Case Against Government Ownership

(*Continued from page* 489)

your chosen activity and you will seek recognition from those in the same activity and from your fellow-men generally, for your proficiency and your success. You will try to know more about that particular thing and to be more proficient than any other. That is what makes the world go around. That is what makes for development and progress. You will not want to be hampered nor restricted by political influence, nor by the rigid rules and regulation which are an essential part of government conduct of any enterprise. Further, if you are successful and if you are efficient, you will seek a reward. If you do something well, if you serve your clients or your customers efficiently, you know they will be willing to pay you well for that service. You will seek a profit as everyone does. You must realize that the socialization of industry means the elimination of the profit motive and are you prepared for that? Do you look ahead to your business or professional activities on that basis?

No, this country of ours has not been built up, it has not progressed, it has not become the envy of the world upon any such theory. Socialization of industry is contrary to all of the traditions and all of the training we have had. It is contrary to our instincts. Do not be misled. Those who contend for government monopoly of the electric industry have not the slightest intention of stopping at that point, if they are successful. From there, those who believe in the socialization of all industry will start their drive for the socialization of all other utilities and eventually to the other great businesses of this country. The time to stop this dangerous movement is now—not later. It will be much more difficult to halt when success has met their effort in an industry so widespread, so tremendous in its scope, so close to the average citizen as the electric utility industry is today.

In conclusion let us agree with Mr. Morris Cooke, the Administrator of the Rural Electrification Administration, who, when asked if it would be a good thing for the federal government to take over the electric business all over the United States, replied: " I should think it would be a calamity."

Let us also agree with President Roosevelt, who said:

"I do not hold with those who advocate government ownership or government operation of all utilities. I state to you categorically that as a broad general rule, the development of utilities should remain, with certain exceptions, a function for private initiative and private capital."

POWER SALES ITEMS

AIR CONDITIONING

"Hotel St. Regis, N. Y., Converts Ventilating System to Cooling." *Heating and Ventilating Magazine,* November, 1936, p. 27. The Industrial Press, Publishers, 148 Lafayette Street, New York City.

"Air Conditioning and Its Effect on Hay Fever and Pollen Asthma," by W. H. Walker. *Heating and Ventilating Magazine,* November, 1936, p. 35. The Industrial Press, Publishers, 148 Lafayette Street, New York City.

"Absorption Refrigeration Unit Cools Brine for Air Conditioning an Inn," by B. H. Jennings. *Heating, Piping and Air Conditioning,* November, 1936, p. 601. Keeney Publishing Company, Publishers, 6 North Michigan Avenue, Chicago, Ill.

CAPACITORS

"Series Capacitor Wipes Out Feeder Flicker," by J. J. Lewis. *Electrical World,* Nov. 7, 1936, p. 3488. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

Largest capacitor by instantaneous response eliminates stubborn flicker originating in industrial load off residential feeder.

DIESEL ENGINES

"Diesel Engine Maintenance, Operating and Outage Data," by Lee Schneitter. Contributed by the Oil and Gas Power Division for presentation at the Annual Meeting of the ASME, December, 1936.

A particularly valuable paper containing original data substantiating the increase in maintenance and decrease in efficiency in regular operation due to engine age. A concrete example of the maintenance and outage data is also given. Single copies are available to members of the EEI on request to the Rate and Power Department.

"Supercharging of Internal-Combustion Engines with Blowers Driven by Exhaust-Gas Turbines," by Alfred J. Buchi, Winterthur, Switzerland. Contributed by the Oil and Gas Power Division for presentation at the Annual Meeting of the ASME, held in New York, N. Y., November 30 to December 4, 1936.

The author discusses the operation of the Buchi exhaust-gas turboblowers for supercharging internal-combustion engines and scavenging the cylinders, and also explains the principles on which the blowers are designed. He presents indicator, temperature, and entropy diagrams for Diesel engines equipped with the blowers, and gives results of tests conducted on the blowers. A number of internal-combustion engines with exhaust-gas turboblowers as used in different types of service are described in the paper. The author also presents a number of curves showing the scavenging effect of the blowers, and the brake mean effective pressure, brake horsepower, and fuel consumption obtained on engines using the Buchi system of turbocharging.

"Hotel New Yorker Installs Second Diesel." *Diesel Power,* October, 1936, p. 632. Diesel Publications, Inc., Publishers, 192 Lexington Avenue, New York City.

Brief description of the plant of the Hotel New Yorker which holds the record of sustained earning during the depression.

"A Diesel Plant in Residential Zones." *Diesel Power,* October, 1936, p. 644. Diesel Publications, Inc., Publishers, 192 Lexington Avenue, New York City.

Brief description of the United States Cabinet Bed Company, Brooklyn, New York, Diesel plant which lowered power costs and produced no annoying noise.

"Internal Combustion Engine Governors Demand Both Careful Design and Construction," by G. C. Wilson. *Power Plant Engineering,* November, 1936, p. 650. Technical Publishing Company, Publishers, 53 West Jackson Blvd., Chicago, Ill.

ELECTRIC FURNACES

"Automatic Handling of Mill Length Shapes During Heat Treatment," by E. J. Janitzky, Carnegie Illinois Steel Company. *Metal Progress,* October, 1936, p. 55. American Society for Steel Treating, Publishers, 7016 Euclid Avenue, Cleveland, Ohio. New York: 25 West 43rd Street.

Precise handling of hot metal by electrically controlled cycle of operations after it is properly heated.

"Electric Furnaces for Porcelain Enameling," by K. E. Kjolseth. *General Electric Review,* October, 1936, p. 479. General Electric Company, Publishers, 1 River Road, Schenectady, New York.

"Electric Arc Furnace Economical for Small Heats," by A. E. Greene. *Electrical World,* Nov. 7, 1936, p. 3480. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

Experimental installation shows competitive costs with cupola melting, a high load factor, a superior product and ability to make quick delivery.

ELECTRIC MOTORS

"Induction Motors on Unbalanced Voltages," by H. R. Reed and R. J. W. Koopman. *Electrical Engineering,* November, 1936, p. 1206. American Institute of Electrical Engineers, Publishers, 33 West 39th Street, New York City.

GAS FURNACES

"Controlled Furnace Atmospheres," by E. O. Mattocks. *Metal Progress,* October, 1936, p. 27. American Society for Steel Treating, Publishers, 7016 Euclid Avenue, Cleveland, Ohio. New York: 25 West 43rd Street.

Operation of gas fired furnaces for various heat treating operations where controlled atmospheres are desired.

"New Ideas in Furnaces." *Metal Progress,* October, 1936, p. 64. American Society for Steel Treating, Publishers, 7016 Euclid Avenue, Cleveland, Ohio. New York: 25 West 43rd Street.

Review of some of the new gas-fired furnaces.

INDUSTRIAL ELECTRIFICATION

"Industry Electrifying in Many Big Strides," by Archer E. Knowlton, Associate Editor. *Electrical World,* Oct. 24, 1936, p. 57. McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York City.

Study of recent accomplishments reveals that electrification is overcoming inertia and competitive methods.

"Industry Electrifies to Modernize." *Electrical World,* Oct. 24, 1936, p. 68. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

A number of small articles illustrating new uses of electric heat, modern lighting and control equipment with modern motor.

"Industrial Electrification." *Electrical World,* Oct. 12, 1936, p. 111. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

Three items which contain ideas for power sales:

Better light yields more, better wire.
Hints on design of industrial wiring.
Simplified sewage pump speed control.

PLANT MODERNIZATION

"Modernizing Pays Way at Bleaching Plant," by D. F. Cronin and R. E. Terry. *Electrical World,* Oct. 24, 1936, p. 64. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

Cherry River Paper Company treats quarter more pulp with fifth less energy due to modernization of plant with speed reducers.

STEAM TURBINES

"The Steam Turbine in the United States," by E. E. Keller and F. Hodgkinson. *Mechanical Engineering,* November, 1936, p. 683. American Society of Mechanical Engineers, Publishers, 29 West 39th Street, New York City.

Developments by the Westinghouse Machine Company.

WELDING

"Welding and Cutting of Metals." *Metal Progress,* October, 1936, p. 215. American Society for Steel Treating, Publishers, 7016 Euclid Avenue, Cleveland, Ohio. New York: 25 West 43rd Street.

Fusion and bronze welding, hard facing and gas flame cutting are treated.

WELL DRILLING

"Oil Wells Drilled Two to Three Miles Electrically," by C. C. Stewart, Southern California Edison Company. *Electrical World,* Oct. 24, 1936, p. 66. McGraw-Hill Publishing Company, Inc., Publishers, 330 West 42nd Street, New York City.

Deeper hunt for oil confirms drift to better materials, stronger structures, more powering of reliable flexibility.

Regulation of Electric Utilities

(*Continued from page* 500)

fessors Petersen and Troger, in their paper on Regional Planning, say:

"The Federal States individually . . . attempted to obtain influence over development; . . . they made the license for the use of water-power, property and other prerogatives under State control dependent upon reservations and imposts. . . . Under these circumstances the electrical industry introduced a new type of corporation, namely the 'mixed-ownership undertaking.' The components of this organization are independent companies set up under the civil law, in which the vote-carrying capital, and with it the proportion of power, is usually divided either equally between the authorities and the private holders or slightly in favor of the former. In this manner the difficulty was removed for the time being, development could proceed unobstructed, while the authorities had the added advantage of being able to utilize the experience of private industry. . . ."

The same authors, speaking of the period under the republic when the Federal States were acquiring and attempting to operate as many utilities as possible, describe the birth of corporations under public ownership, as follows:

"All governments—Reich and Federal States—originally attempted to operate their plants under their own management. The disadvantages of assigning this duty to the ministries were soon perceived. In addition to numerous political influences, the handicap to flexibility of management increased with the number of plants; decisions as to raising money, participations, building programs, extents of territories, etc., in many instances even required legal assent.

"One after the other, the Governments, therefore, had to establish independent corporations, generally joint-stock companies, and to entrust them with the management of the plant. The individual undertakings were combined to form independent holding companies, and the cooperatives were grouped in associations under common management for both administration and operation wherever the relative positions of the supply areas allowed it."

Following the accession of the present National-Socialist regime and the suppression of the sovereignty of the Federal States, in 1933, the Reich, or German State became supreme. Important legislation affecting electricity supply was enacted in conformity with the principles of the regime, concerning which the authors, Messrs. Krecke and Seebauer, quote two that have special application to the theory of regulation for electric utilities. They are as follows:

(1) The State and its corporations do not, on principle, wish to go into business. On the other hand, every undertaking in all its actions must consider the interests of the community.

(2) State guidance of economy cannot and should not replace the initiative and independent responsibility of individuals. On the contrary, ample scope should be given to the valuable forces of individual responsibility as an essential condition of progress. The idea of responsible self-management of industry must be maintained in the organization to the largest extent possible.

During 1934 legislation was enacted looking toward the amalgamation of all of the culture, as one might say, of the electricity supply industry, but not its property, into an association, the "Reichsgruppe Energiewirtschaft" that is strongly suggestive of guild practice. There were also legal requirements for very complete informational returns, ultimately to the Reich Ministry of Economy.

In December, 1935, the Energy Economy Act was enacted. This law definitely places German utility undertakings under the control of the State, irrespective of legal form or conditions of ownership. The law contemplates that control of the industry will be exercised by control of the construction of new plants and distributing systems or extensions and additions thereto, and by control of tariffs. While no specific program is laid down with respect to control of tariffs there are requirements for the publication of tariff schedules and conditions of service and for supply at the published tariffs, provisions whereby the Ministry can "adjust" tariffs to "economic necessity" by regulations, and provision for regulations covering franchise assessments. There are also provisions for expropriation in the case of a utility "proven incapable of fulfilling its duties" and stipulations concerning imports.

The authors quote a portion of the introductory paragraph of the law, outlining its purposes, which may have a familiar ring to Americans:

". . . to insure centralized control of utilities as an important basis of economic and social life; in the coordination of efforts of all forces engaged in the national economy and of the public bodies concerned, to apply economically in the public welfare, the various sources of energy; to preclude economically bad effects of competition; to provide rational equalization by interconnecting systems, and by all these means to make energy as reliable and cheap as possible. . . ."

Other Countries

It is impossible within the limits of an article such as this, to describe in adequate detail the regulatory practices of the remaining industrial countries of western Europe. Although many of the smaller countries have employed methods that are worthy of serious study, they are not only disqualified by size from a useful comparison with American conditions, but in each of the cases that deserve critical attention and have not been included here there is some special condition leading to a more or less one-sided development of electricity supply. Thus Belgium and Holland have coal but no hydraulic power, while Italy, Sweden, Norway and Switzerland have hydraulic power but little or no coal. In a more extensive study these circumstances could be taken into consideration and much benefit might be derived from study of their practices under the imposed conditions.

CONVENTIONS AND MEETINGS

JANUARY

21-22 Transmission and Distribution Committee, Philadelphia, Pa.
25-27 American Society of Heating and Ventilating Engineers, St. Louis, Mo.
25-29 American Institute of Electrical Engineers, New York, N. Y.

FEBRUARY

8- 9 Electrical Equipment Committee, Cincinnati, Ohio.
14-18 National Electrical Manufacturers Association, New York, N. Y.

APRIL

26-28 Chamber of Commerce of the U. S. A., Washington, D. C.

MAY

3- 7 Technical Committees, Edison Electric Institute, Edgewater Beach Hotel, Chicago, Ill.
10-14 National Fire Protection Association, Chicago, Ill.
23-27 National Electrical Wholesalers Association, Hot Springs, Va.
24-27 National Association of Purchasing Agents, Pittsburgh, Pa.

JUNE

2- 4 EDISON ELECTRIC INSTITUTE, Palmer House, Chicago, Ill.

"The Causes and Locations of Accidents," by C. R. Beardsley, will be published in the January issue.